PRODUCT ENGINEERING

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DESIGN OF THE SIXTEEN-CYLINDER CADILLAC

WHEN a manufacturer possessing the reputation, which the Cadillac Motor Car Company is fortunate enough to enjoy, decides to develop a new product, a particularly heavy responsibility rests upon the engineering department charged with creating the new product, selecting the materials best suited for use in it, seeing that the components themselves and the product as a whole are properly tested and refined, and, finally made ready for manufacture. The task is made even more difficult if the new design is a radical departure from prevailing accepted practice.

This was the actual condition existing when we decided to build our new sixteen-cylinder car. Our engineering department conceived the design and carried through the work of building and testing the engine, as well as the chassis, of which it is the most important unit, in a manner that is a credit, not alone to the chief engineer, but to every member of his very capable staff. It is a pleasure to acknowledge this fact and to say that, in our estimation, the engineering of the product is one of the most important phases of present day industrial work.

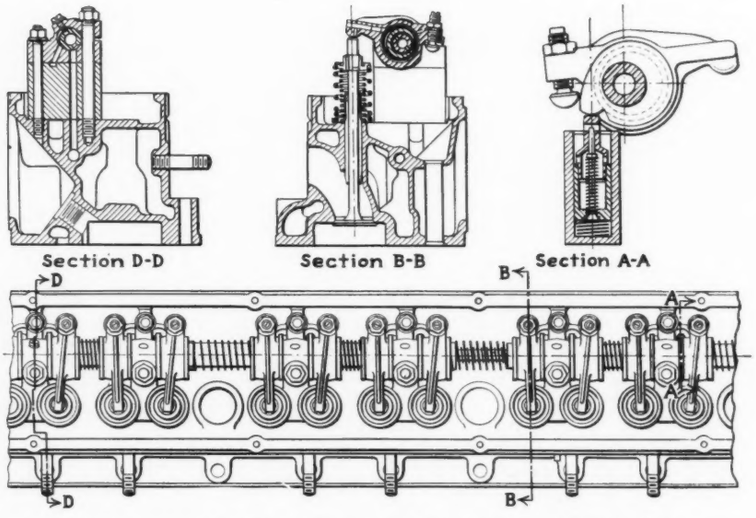
L. P. Fisher

President, Cadillac Motor Car Company

Reasons Behind THE SIXTEEN-CYLINDER CADILLAC-

By ERNEST W. SEAHOLM
Chief Engineer, Cadillac Motor Car Company

Demand for a distinctive car of high power and exceptional performance was primarily responsible for the new car design



THE CYLINDER HEAD, sectional and partial plan views, showing arrangement of valves and the automatic take-up mechanism

WHY sixteen cylinders?—That is the inevitable question when the new Cadillac car is mentioned. Designers in particular are entitled to know the answer. It lies in the fact that Cadillac saw a potential market for a car of advanced design and the highest grade of workmanship. Such a car, it was felt, would appeal to a class of purchasers who today are likely to choose one of the finest of European cars merely, or largely, because in so doing they get something distinctive, well beyond the price range of fine American cars made in quite large quantities. Our purpose was not to create a product to replace the present Cadillac eight, but to add another and finer car to the Cadillac-LaSalle line,—one, not only distinctive in appearance, but also in performance and in ability to give long service with minimum attention.

While an eight of requisite power could be built to propel so large and substantial a vehicle as was projected, cylinders would be of too great a volume to assure the best of combustion conditions, and reciprocating parts would be too heavy for the smooth and substantially vibrationless performance demanded. A twelve-cylinder engine received favorable consideration, but it was felt that, for the degree of refinement and the large power output desired, a sixteen-cylinder V-type engine would prove most satisfactory.

We decided, therefore, to design such an engine. Only a 45 deg. "V" would give evenly spaced power impulses. With an engine of the desired height and width there was not sufficient room in the "V" to permit of an L-head design. Overhead valves seemed to offer the best solution, providing they could be made noiseless. They also would assure a high volumetic efficiency and increase power output. If we could find a practicable way to eliminate the clearance between the valve stems and rocker arms, quietness would be attained. We found a solution in the automatic valve silencer illustrated in accompanying cuts.

Other problems presented themselves, but from this point on the sailing was relatively clear. Engine length had to be minimized to assure a rigid crankshaft and to secure other advantages. We could use nine main bearings, but either the space occupied would increase engine length unduly, or most of the bearings would have to be narrow, and it is difficult to keep an oil film in narrow bearings. A five-bearing shaft would make it possible to remove any piston and rod assembly through the crankcase without disturbing the head, and would yield other advantages. We chose to use five main bearings of $2\frac{5}{8}$ in. in diameter and varying in length from front to rear as follows: $2\frac{3}{16}$, $1\frac{3}{8}$, $1\frac{1}{2}$, $1\frac{3}{8}$ and $3\frac{9}{16}$ in. As it turned out, nearly 25 per cent of the total length of the crankshaft is supported in the main bearings. All main and crankpin bearings are babbitt-lined and steel-backed, those in the big ends of the rods being cast directly into the rods. All these bearings are diamond-bored to ac-

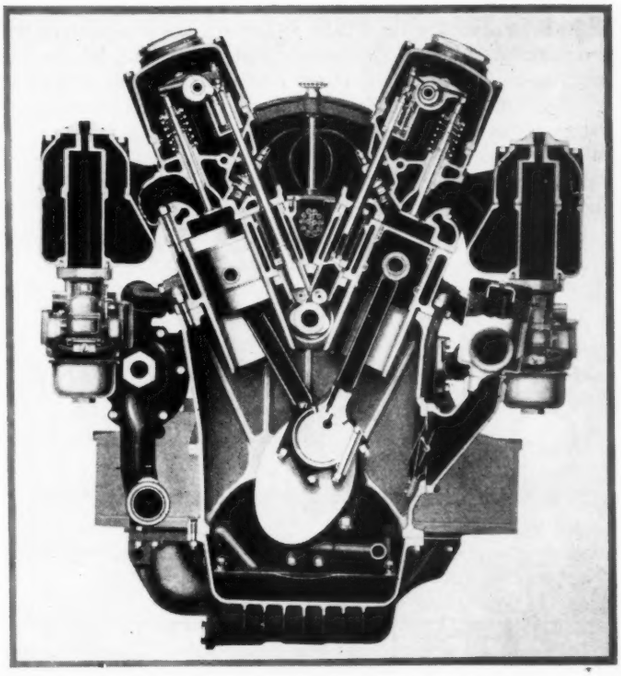
curate size, and no hand scraping is done. The crankshaft has integrally forged counterweights, is carefully balanced, and is fitted with a harmonic balancer designed by the General Motors research laboratory. This balancer has no friction surfaces, and is not affected by moisture, as is the case with some vibration dampers.

Our favorable experience with side-by-side connecting rods and a staggered cylinder arrangement in the Cadillac and LaSalle eights led us to follow the same design in the sixteen. Each rod bearing is $1\frac{1}{8}$ in. wide. By adopting a relatively short (4 in.) stroke, and using crankpins $2\frac{1}{2}$ in. in diameter, the crankshaft was made extremely stiff. The crankshaft might even be referred to as an eccentric shaft, for in end view the crankpins overlap the main bearings $\frac{9}{16}$ in. and the checks are correspondingly short, —one of the factors making for stiffness. End thrust is taken on the center bearing.

In effect, the crankshaft is like two four-cylinder engine, single-plane shafts, one of which is cut in half and the two parts added to the ends of the other shaft with the plane of the end portions at right angles to that of the center portion, but, of course, the crankshaft is a one-piece forging of high-carbon steel. It is drilled for pressure lubrication to each main bearing and to bearings at both ends of the rifle-drilled chrome-molybdenum steel connecting rods. The latter measure $9\frac{1}{4}$ in. center to center, and are of H-section with bronze bushings at the piston pins.

Cylinders are 3 in. in diameter and are cast in two separate blocks with simple core work. The final finish is by honing. To reduce over-all height, the cylinder barrels are designed to project several inches into the crankcase, which, because of its depth and heavily ribbed bearing seats, forms an extra rigid base for the engine. It is cast from an alloy of silicon and aluminum, and is stiffened further by the two cylinder blocks when they are bolted in place against the crankcase.

Two simple expedients tend to prevent warping of the long cylinder blocks as a result of differences in heat expansion. Each of the two exhaust manifolds is cast in three parts, with sleeve joints between the center and end sections. These joints permit the highly heated manifolds to go and come without distorting the blocks. The latter are held to the crankcase by closely - fitting studs and nuts along the outer edges of the attaching flange. If similar short studs were employed at the inner edges of the flanges, they would be difficult to reach at the bottom of the "V". Consequently the inner studs are made long enough to extend upward through the cylinder heads which they also help to hold in place. Holes in the lower cylinder block flange have enough clearance to compensate for any difference in expansion between the block and the crankcase.



ARRANGEMENT of cylinders, valves, manifolds, carbureters and other parts in the engine

Cast-iron pistons are employed in preference to aluminum alloy because our experience has been that a smaller clearance can be used and that, in consequence, less noise is produced. Wear also is less rapid. The clearance allowed at the top is 0.0025 to 0.0035 in. and at the bottom 0.002 to 0.003 in. Each piston has three Perfect Circle compression rings and one oil ring. The pin is locked in one boss only, and thus is free to expand axially without distorting the piston.

Cylinder heads, shown in an accompanying drawing, have flat combustion chambers, approximately elliptical in plan view. These chambers are machined to accurate size and the form chosen is the one found by actual test to give best combustion conditions. The compression ratio is quite high, $5\frac{1}{2}$ to 1, and accounts in part for the excellent economy. Fuel consumption under full load runs as low as 0.6 lb. per b.hp. hour. The maximum output occurs at 3,400 r.p.m. and is 175 horsepower. Maximum torque is 320 lb. ft. at 1,400 r.p.m. With this power a car having the heaviest body we supply and having the largest gear reduction, can attain a maximum speed of at least 85 m.p.h. Chassis with lighter bodies are capable of speeds well above 100 m.p.h. and can hold this speed for long stretches without overheating the engine.

All valves are interchangeable. They are made from Silchrome steel, and are so placed that, should a stem break, the valve cannot fall upon the piston. Valves have flat heads and 45 deg. seats. The clear diameter is $1\frac{5}{16}$ in. Double helical springs hold the valves to their seats. The camshaft, located just below the "V," is made hollow to carry oil under pressure to all its five bearings. Its 32 cams are forged integrally. Roller-type cam-followers actuate the tubular rods, which are cupped at their upper ends, where they bear against the spherical ends of adjusting screws threaded into the rocker arms.

Each rocker is fitted with a bronze bushing upon which it turns. These bushings have an eccentric bore, forming a bearing upon the through rocker shaft, and are flanged at one end. The flange is not circular, but is notched to form a short lever, which rests against a plunger pressed upward by a comparatively light spring. This pressure revolves the eccentric bushing, thereby lowering the rocker arm until its two ends contact respectively with the valve stem and the push rod, thus taking up all clearance, and eliminating the noise that would result when the valve is actuated with clearance.

Since the plunger forms part of an oil dashpot, it cannot oscillate when the valves are functioning, for the space in the cylinder below the piston is filled with oil

which can escape only very slowly through the annulus between the piston and cylinder. The clearance between these parts is only 0.002 in. In the piston is a small check valve opening downward and held to its seat by a light spring. When the plunger is moved upward by the spring below it, the suction created causes this check valve to open and permits the oil within the piston to flow through into the space below. All this occurs automatically, for the piston always is filled with oil overflowing from the rocker mechanism above. In consequence the space below the plunger is kept filled.

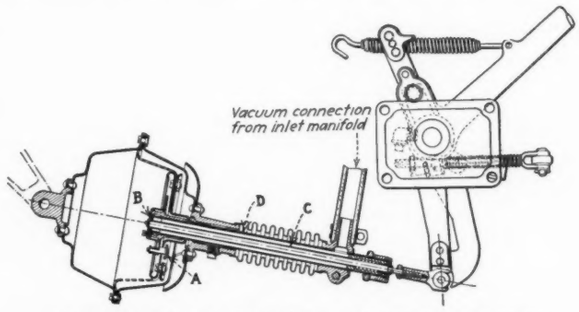
Only the entrance of foreign matter can upset the functioning of this valve clearance take up mechanism, and this is guarded against by providing an external "A.C." filter, through which all oil entering the valve compartments must pass. Oil enters this filter from the by-pass near the discharge of the gear-type oil pump, and is delivered into the two hollow valve rocker shafts, by which it is distributed under pressure to all rocker bearings. Oil passing these bearings quickly fills the valve chambers, which are tightly closed by cast aluminum covers. It then overflows, following down beside the pushrods, past the tappets and cams, which it lubricates, into the crankcase, and finally through a screen, covering the entire lower section of the crankcase, into the sump. External fins on the aluminum lower case help to keep the oil cool, while transverse internal partitions prevent it from swashing about.

To assure ventilation of the crankcase, and thereby reduce or prevent any accumulation of condensed fuel or water, an air bell, facing the cooling fan, is provided. This bell leads through an air filter and past a thermostatically controlled butterfly valve to the crankcase, in which the pressure is maintained slightly above atmosphere. Outlet pipes, leading from the rear of each valve compartment, carry vapors off below the car.

ENGINE cooling is by water circulated by a centrifugal pump with two outlets. The pump is located on the right side of the engine and is driven by an extension of the generator shaft. One pump discharge pipe leads to the center of the right block, while the second is connected to a similar opening on the left block by a copper pipe placed transversely and cast into the rear end of the crankcase.

Molded rubber hose forms the radiator connections. The radiator is provided with vertical shutters operated by one of the seven thermostats used in this car. Of the other six, two are in each carbureter, one in the crankcase ventilation control, and one in the lighting generator for limiting its current output.

We chose a Morse chain with an automatic take up for the camshaft and accessory drives because it is silent in operation, when compared to gearing. A steel sprocket is used on the crankshaft and that on the camshaft is of cast iron. The timer head and oil pump are driven by vertical shafts through helical gears off the front and rear ends, respectively, of the camshaft. In the ignition head, there are two breaker points operated by an eight-lobe cam. Ignition wires come off horizontally from the two-deck head and are led aft through a metal conduit in the "V" to the respective plugs, one of which is placed between the valves in the center plane of each cylinder. A novel feature of the system is that the ignition coils are placed in sealed compartments inside the radiator shell, where they are near the ignition head. Switch wires are carried forward from the dash through the stay rods that position the radiator.



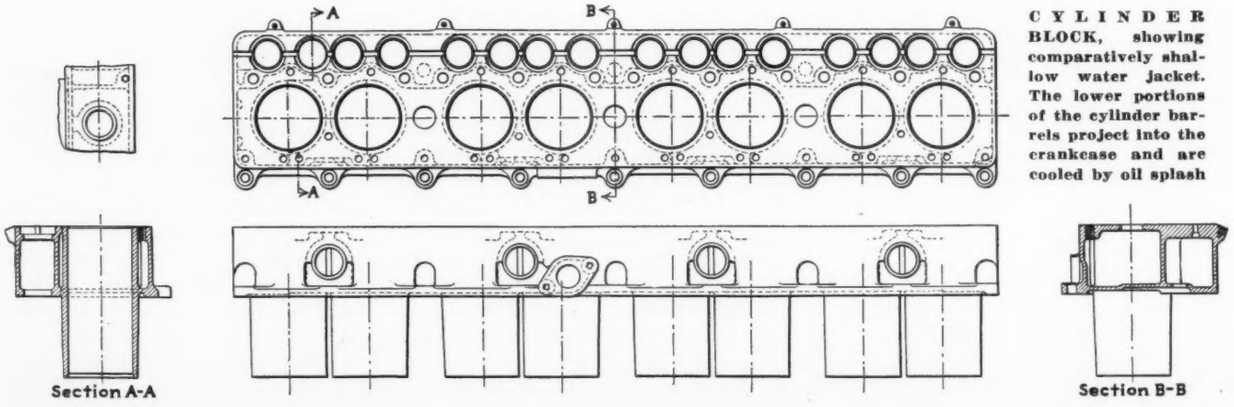
VACUUM BRAKE ASSISTER. The atmospheric valve A and the vacuum valve B are actuated by the tubes C and D through interconnection with the brake pedal

With so large an engine a rigid support is of great importance, and this is provided by bolting the front end bracket to a pair of diagonal frame braces and the arms at the flywheel housing to the main frame channels. A fifth support is provided at the rear end of the gearset, which is flanged to the flywheel housing in the usual way. At each support is a rubber mounting designed to cushion the engine and insulate the body from engine noise.

Each cylinder block is fitted with a 1½-in. Cadillac carburetor fed from one of the vacuum tanks mounted in front of the forward section of the double dash. The vacuum for this feed is created by a separate vacuum pump driven off the camshaft.

The two vacuum tanks, the oil filter covers and oil filler caps, hose clamps, acorn nuts, and many other parts seen when the hood is lifted, are chromium-plated, as are also the radiator shell and many other external parts of the car.

Except for the increased length of the chassis frame

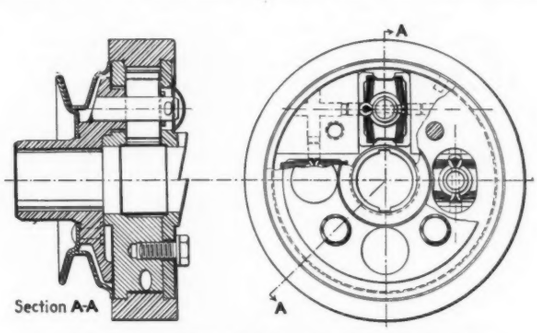


CYLINDER BLOCK, showing comparatively shallow water jacket. The lower portions of the cylinder barrels project into the crankcase and are cooled by oil splash

and the increased size of parts necessary in a larger and heavier car with a more powerful engine, the 16-cylinder Cadillac chassis virtually duplicates that used in the Cadillac eight. It also incorporates such well-tried construction as is found in the Synchro-Mesh gearset, torque-tube enclosure for the propeller shaft, spiral-bevel rear axle gears and other parts. A worm-and-sector steering gear mounted in Timken roller bearings, in combination with a large-diameter Pyralin-covered steering wheel with die-cast aluminum framework, serves to make the steering easy. A "modulator" fitted at the front end of the left front spring is designed to cushion and absorb road shocks and prevent them from reaching the steering wheel. Springs have metal covers containing sufficient lubricant for many thousand miles of service.

IN SO large and fast a car the most effective brakes had to be provided on all four wheels. The design follows that used on the Cadillac eight with a vacuum type "assister" added to make brake operation easier. The assister is operated by the partial vacuum in the inlet manifold. As its name implies, the assister does not supply all the pressure needed to apply the brakes, but is arranged to augment automatically the pressure of the foot upon the brake pedal, in proportion to pedal travel. As the accompanying drawing indicates, the assister employs a diaphragm rather than a piston. Braking effort is divided equally on all four wheels.

All bright-work on headlamps, bumper and other external parts is either chromium plated or polished stainless steel. The latter metal is used for moldings on the running boards, which are of steel covered with walnut and rubber strips. A chromium plated screen mounted in front of the radiator carries the Cadillac emblem

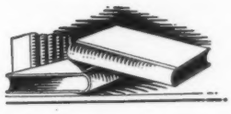


A FLANGED HUB forming part of the harmonic balancer, is attached to the front end of the crankshaft. The flange carries four pins, each of which is straddled by a pair of leaf springs whose ends are supported in and form a flexible drive for a "floating" flywheel

finished in gold leaf. Another item of equipment that is noteworthy is the pair of horns mounted beside the headlamps. Our aim was to secure a warning signal that would be striking and characteristic of the car. This we obtained very effectively by setting the two horns for different periods, and connecting them so that they sound simultaneously. The result is that they produce a beat note that is distinctive.

Numerous details, such as the mounting of equipment on both front and rear sections of the dash in such a way that no bolt or screw heads show from the outside, can be cited to indicate the care used in making a car that will "look the part" as well as perform according to the highest standards, but enough has been said to show how the major problems in the design were solved.

Books for Engineers



THE BALANCING OF ENGINES. FOURTH EDITION. *By W. E. Dalby, professor of engineering, Imperial College of Science and Technology, London. Three hundred twenty-one 9x6 in. pages. Cloth board covers. Two hundred eighteen illustrations. Published by Longmans, Green & Company, New York, N. Y. Price $8.40.*

SINCE the first edition of this book was brought out in 1902 there have been great changes in the design of machines to which the theory of balancing applies, but the author's original method of solving balancing problems and of finding the balancing weights in a practical way on the drawing board has been found effective. In this fourth edition the method is continued, with amplification of the data and experience gained by research.

The number of machines for testing unbalance that have been brought out within the last few years is one measure of the importance now being given this matter by engineers. In automobiles the car buyer looks for something near perfect balance to give him freedom from vibration, noise, and excessive wear. Bridge constructors look for balanced locomotives to reduce the required allowances for hammer blow, torsional oscillation, and swaying. The designer of ordinary industrial machines must also balance the rotating parts if he is to obtain the quiet operation now demanded by the users. This book is an outstandingly complete treatise of the subject for the technical designer. It divides the subject into logical chapters, illustrating each with ample examples and drawings.

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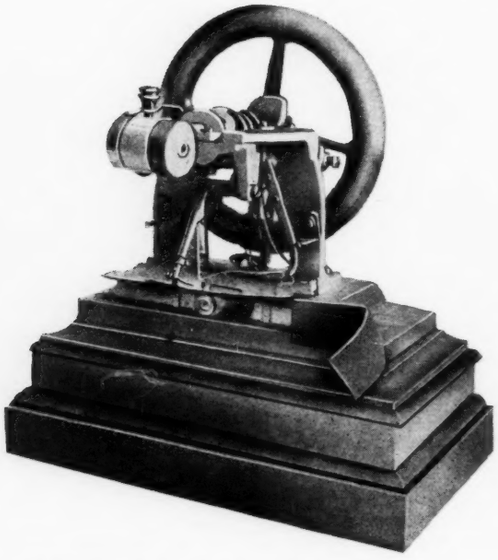
MACRAE'S BLUE BOOK AND HENDRICKS COMMERCIAL REGISTER. *Twenty-six hundred and forty pages, 8½x11 in. Cloth board covers. Published by MacRae's Blue Book Company, 18 East Huron Street, Chicago, Ill. Price $10.*

LISTINGS of many thousands of manufacturers in every division of industry form the content of the book. It is intended primarily as a reference for any firm or individual desiring to know the sources for nearly any product or raw material produced in industry.

The book is divided into three main sections to assist the reader. The first is an alphabetical listing of names and addresses. The second section sorts this alphabetical list under a product list, also alphabetically arranged. The third section lists the names of companies whose products are known under trade names. These trade names are set up alphabetically.

The value of such a book is well known to anyone who answers questions that have to do with sources for industrial products, with locations of companies and with identification of the makers whose names are secondary to the trade names of their products. Such a book can also easily find considerable use in engineering departments, where it saves much time ordinarily lost in calling upon other departments for information.

EIGHTY YEARS of SEWING



ELIAS HOWE, in 1846, patented the first commercially successful lock stitch sewing machine. The cloth was pinned to a feed-strip

SINGER'S patented lock-stitch sewing machine, 1851, was the first successful machine using the rocking treadle, horizontal arm and cabinet construction

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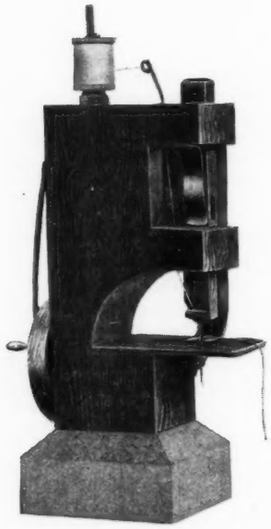
Photographs through the courtesy of the Singer Manufacturing Company and the Willcox & Gibbs Sewing Machine Company.

BACHELDER, in 1849, invented the first self-feeding sewing machine, restricted to sewing a straight seam. In 1854 Allen B. Wilson, whose machine is shown in the picture, patented the four-motion feed bar which permitted sewing curved seams



SINGLE THREAD chain stitch machine patented in 1856 by James E. A. Gibbs. It contained the essential principle used today in all chain stitch sewing machines

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MODERN motor driven sewing machine with built-in motor, knee control, and electric lamp on horizontal arm

SINGER electric sewing machine of 1889, with balance wheel type motor. Water motor and spring motor machines had appeared as early as 1875

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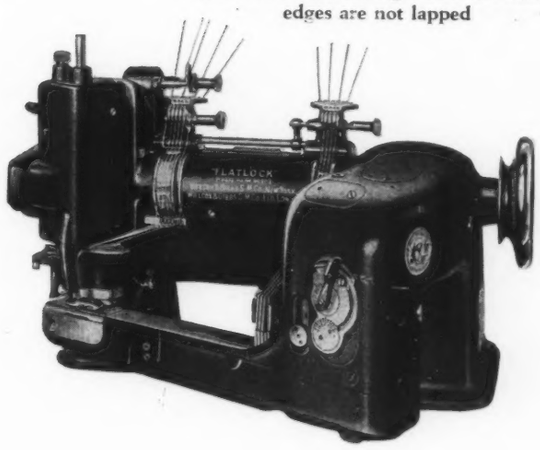
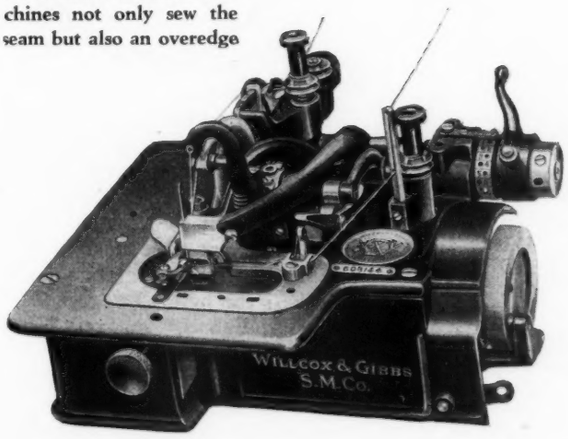
NINE THREADS sewn in one operation, and the raw edges of the cloth trimmed before sewing. The two cloth edges are not lapped



MACHINE DESIGN

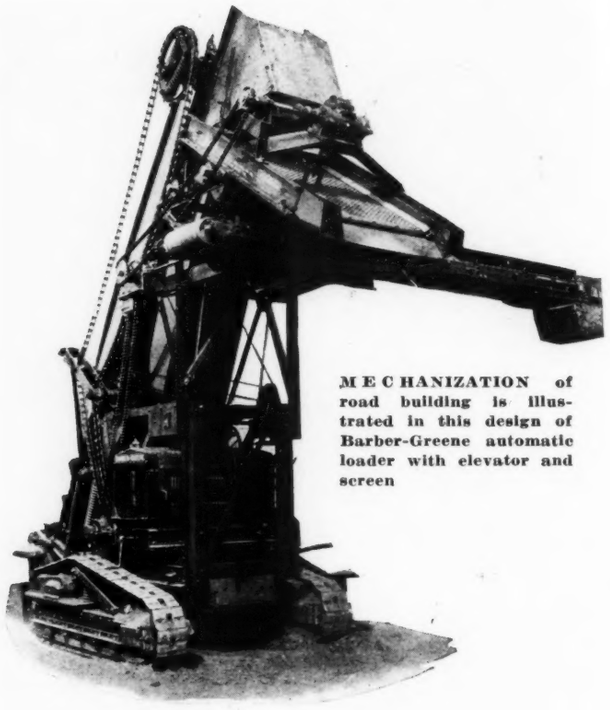
MODERN industrial machines not only sew the seam but also an overedge



1930 Though the modern sewing machines operate on the same basic principles as invented almost eighty years ago, yet the designers have increased the capacity several thousand per cent, developed combinations of stitches, and at the same time added beauty, lightness, and compactness.

Design Developments in ROAD MACHINERY

By GEORGE S. BRADY
Managing Editor



MECHANIZATION of road building is illustrated in this design of Barber-Greene automatic loader with elevator and screen

FOUR YEARS have made remarkable changes in the design of roadbuilding and allied machinery, of which more than $10,000,000 worth are sold annually in this country, and large quantities exported. According to competent authorities it is largely within this period that road equipment has been lifted out of the old-fashioned agricultural machinery class as far as progressive design details are concerned. In the use of high-grade alloy steels, anti-friction bearings, modern lubrication, beauty and durability in design, the present pieces of construction equipment are now apparently well abreast of machine tools, which have been considered as the leaders in the incorporation of new materials and parts.

The 1930 Road Show, held in connection with the annual convention of the American Road Builders' Association at Atlantic City, January 13-17, showed that "steam shovels" have practically ceased to exist. The change to gasoline engine driven "power shovels" required complete redesign of clutches and transmission, which has been effected with complete success. One shovel, the "Lima 101," is completely equipped with anti-friction bearings. In the new Koehring "Model 401" shovel, displayed at the show, every gear is inclosed and running in oil. The same idea was carried out in this company's paving mixer. In fact, practically every company has attacked with success the problem of keeping clean and well-oiled moving parts on a class of machinery that works and stands in dirt in all kinds of weather.

The popular term "steam roller" must soon also be dropped from the vocabulary, and is replaced by the more modern "motor roller." Only one steam-operated roller was shown at the show. Motor rollers appear now in graceful lines that rival those of the automobile, and in bright red, green, and orange colors. It necessitated the design of a special transmission to make the change from steam to gasoline, a road roller requiring great flexibility and instant change of direction without skidding to prevent furrowing of the pavement.

Excavating 36,000 cu.yds. in 38 ten-hour days is a record made by one of Link-Belt's trench hoes! These machines show intelligent modern machine design throughout. The frame under the gearing is one-piece annealed cast steel finished accurately where required, and the cast-steel rotating base is also finished in jigs. The swing rollers are completely covered but easily removable. Powerful band clutches are located at the sides of the drums. Swing and travel clutches are of the expanding-band type. All gears are of special steels, cut from the solid. The chain drive is completely inclosed and runs in oil. The crawler shoes are of chromium steel, while manganese steel is used to obtain wear-resistance in the dipper. The Link-Belt job can certainly be considered as typical of the best advances. The Northwest's line of shovels also showed remarkable design features, simplicity and accessibility being the keynotes.

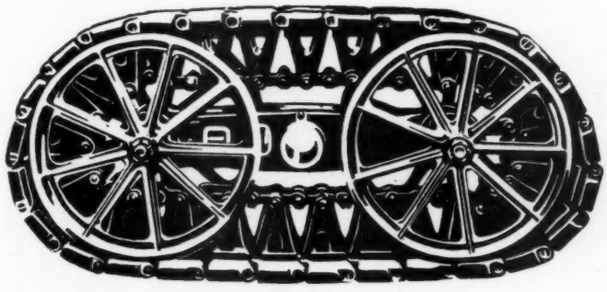
ROAD MACHINERY builders are leaving special jobs to specialists. This French & Hecht tractor wheel has steel rim, spokes forged into the hub, expanding wedges and auxiliary weight

THE "Economy" dipper tooth is of Amsco manganese steel. The bases last indefinitely, and the teeth can be replaced readily in the field

Tractors were probably somewhat

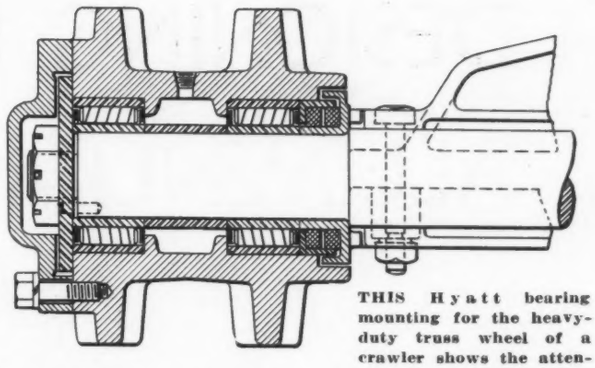
ahead of other kinds of construction machinery in design up to a few years ago, possibly because of experience during the war, but still they have undergone complete redesign. The Allis-Chalmers "Monarch" job is typical. The "75" weighs 23,600 lb., and has a rated capacity of 59 hp. at the drawbar. When analyzed from a designer's standpoint it appears as a remarkable piece of modern machine design. The 4-cylinder Monarch-LeRoi engine has a special-iron crankcase cast in two parts. The poppet-type valves are one-piece Silcrome forgings. The main bearings are bronze-backed, and connecting rods are of special Lynite. The engine is fitted with Zenith carburetor, and Purolator oil filter.

THE crankshaft is of drop-forged nickel-chromium steel, and heat-treated special alloy steels are used in the transmission and for shafts and drives throughout the machine. The steering clutches have 15 disks of saw steel, the eight driven disks having Thermoid linings. The master clutch is of the single dry-plate type using cast iron against Thermoid linings. The clutches are dust proof and readily removable. The rear axle is of heat-treated carbon-managanese steel. The front weight of the tractor is carried through coil springs to a bracket on an equalizer bar which in turn is carried in the truck frames through ball and socket joints. Timken roller bearings carry the front sprocket axle. Hyatt roller bearings carry the truck wheels. These wheels have forged-steel rims shrunk on malleable-iron hubs. An electric starter, and an electric lighting outfit top off the equipment of this tractor, together with bright-colored weather-proof paint to add to its appearance.



THIS "Athey" truss wheel for a 5-yd. wagon is comparable in its action on the ground to a round wheel 15 ft. in diameter having a 14-in. face. It makes possible extremely heavy loads with great power saving

It doesn't seem possible that much new in design could be expected in the drab snow plow, but in this and in scrapers several companies showed as great an influence of the modern designer as in the previous cases. The Austin-Western scrapers, graders, and maintainers shown were examples of powerful machines incorporating the latest in materials and units as well as grace in design. Caterpillar and Stroud both showed graders operated by a drive shaft taken off from the pulling tractor. The Root Spring Scraper Company's "Big Buster" plow was shown equipped with hydraulically operated extension wings easily adjusted from the driver's seat for banking snow. This company also displayed a light plow for use on ordinary pleasure cars which was all arc-welded.

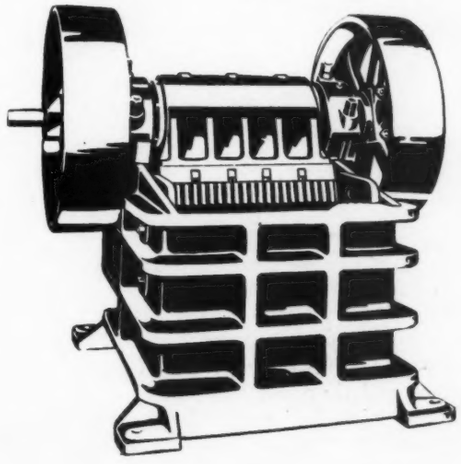


THIS Hyatt bearing mounting for the heavy-duty truss wheel of a crawler shows the attention to positive closure against dirt for severe conditions

As a result of the employment of alloy steels, rock crushers have been reduced in size, while at the same time effective life has been increased. Jaws are made reversible in order to double the life in the field. Rigidity is secured by casting the frames solid, by careful balancing, and by the machining of fitting parts. Some of these machines incorporate anti-friction bearings.

The Killifer Manufacturing Corporation showed the "mole drainage machine," which tows a weight behind a plow blade several feet below the ground surface, and rounds out a circular conduit automatically.

MATERIALS and parts manufacturers have played a most important part in this modernization of road machinery. The producers of manganese steel castings exhibited examples of dipper frames and teeth, and impeller blades and side plates for sand pumps, all of which have been successfully incorporated in machines. One company showed a remarkably varied line of alloy steel castings for tread links, draft gears, gears, dipper teeth, and frames. A number of the makers of anti-friction bearings were represented at the Show, and one maker of rock crushers claimed 50 per cent increase in power saving by the use of roller bearings in the pitman and frame, with easier and steadier operation. The pressure oil and grease systems were apparent on all types of equipment, as well as filters for crank and gearcase oils. Standard makes of drive chain have been widely adopted in place of the older types of common link chain. An interesting feature brought out at the Show was the extent to which such parts as wheels have been specialized. This specialization has resulted in quantity production methods that permit the incorporation of modern design into all details of the wheels. Stronger and better appearing wheels with less weight have been developed.



MANGANESE-STEEL castings and complete roller-bearing installations are features of this "Wheeling" crusher

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DESIGNING FOR ALUMINUM DIE CASTINGS

Latitudes And Limitations

WASHING MACHINE impeller support showing possibilities in cored castings

DOUGLAS B. HOBBS
Aluminum Company of America

PORTABLE vacuum cleaner body, weighing only 0.56 lb., die cast in aluminum alloy

DIE CASTING is adapted to the rapid production of large quantities of castings. Briefly the process consists in forcing molten metal under considerable pressure into steel dies. The castings thus produced have certain advantages over sand and permanent mold castings. The main characteristics of die castings — their extreme accuracy, uniformity and superior finish—are the result of not only the method by which the castings are made but also the fine art developed in die construction. Thinner cast walls are possible with a consequent saving in weight; holes can be cored to very close tolerances; and the dimensions of the casting can be accurately controlled. Very little, if any, machining is necessary on die castings because they represent the highest degree of fabrication of any type of casting. The polishing and finishing operations are also simplified and made much less expensive because of the excellent surface a die casting possesses.

As a rule, the die-casting process is employed only when the quantity of castings required is sufficient to justify the cost of dies. Since this initial expenditure must be distributed over the number of castings produced, it is obvious that this process is ordinarily adapted only to quantity production. But even with a limited production, it is sometimes economical to use die castings. For example, there are instances in which the cost of engraving or machining a part cast by any other process is high enough to offset the otherwise excessive die cost per unit that a small number of castings entails.

The die-casting process is an outgrowth of the linotype process, and was developed originally for use with tin and lead alloys having good fluidity at a low liquid temperature and little shrinkage while passing into the solid state. Later, zinc alloys were used. These did not have the fluidity nor the low shrinkage of the lead and tin alloys, but still possessed a low melting point. Aluminum alloys were not in general use for die casting until the war period. The higher temperatures involved retarded their development until suitable materials for dies were available. Today alloys of all of these metals are employed, the choice for a given casting depending upon the requirements which must be met. Where the properties of lightness, pleasing appearance, corrosion resistance, permanence of dimensions and shape, and ability to withstand higher temperatures are desired, one of the aluminum alloys is generally selected.

The aluminum alloys first used for die casting were modifications of the aluminum-copper alloys commonly employed in foundry practice. They usually contained more than the standard 8 per cent copper, generally 10 to 14 per cent. The high additions of copper were made to obtain greater fluidity and lower shrinkage, but had the undesirable effect of destroying the ductility of the alloy.

The introduction of silicon, either alone or in combinaton with copper as a hardener in aluminum alloys, gave

a marked impetus to the aluminum die-casting industry. The addition of silicon imparts to the alloy a high degree of fluidity, a low shrinkage and good physical properties. With both the aluminum-silicon and the aluminum-silicon-copper alloys, extremely thin sections of relatively great length and width can easily be cast.

Nickel and tin are sometimes used as alloying elements. Nickel improves the polishing properties of the alloy, and tin the machinability. Tin is, however, an undesirable addition from the standpoint of casting characteristics. Because of the hot-short effect it produces, it is frequently impracticable to die cast aluminum alloys containing more than 1.5 to 2.0 per cent tin.

The more objectionable impurities in aluminum die casting alloys are zinc and iron. Zinc is usually found in alloys which have been made from remelt or reclaimed materials. It renders the alloy hot-short, and for this reason it is desirable to keep the zinc content as low as possible. This can be accomplished by using suitable grades of aluminum alloys and by carefully avoiding contamination in plants in which both zinc and aluminum alloys are produced. Iron results from holding the alloys in the iron pots of the casting machine and regardless of how much care is exerted, some iron will invariably be picked up. Aluminum alloys with excessive amounts of iron become more or less sluggish and are hard to cast. It is important, therefore, that the iron content be kept as low as operating conditions allow. For the best results it should not exceed 2 per cent.

Some of the aluminum alloys commonly employed for die-casting purposes contain from 2 to 14 per cent of copper, with or without silicon. From 2 to 8 per cent of silicon may be used. Sometimes nickel is added, or silicon is used alone with the aluminum. Tensile strengths range from 30,000 to 38,000 lb. per sq.in. Careful choice is necessary for casting qualities.

THE fact that aluminum alloys have a higher melting point than lead, tin and zinc alloys required the development of special alloy steel dies. The ordinary carbon steels used for making dies for the other white metal castings are totally inadequate to withstand the reversals of stress and temperature set up while filling a mold with molten aluminum at high pressure. In addition, molten aluminum dissolves and erodes the surface of a carbon steel die, materially shortening its life. A number of special alloy steels have been developed commercially, and some of these are in quite general use. The material employed for all dies and cores is not necessarily restricted to one steel, and at times several different grades of steel are used for the different parts of the same die.

The layout, design and construction of the die present many problems of vital importance to both the customer and die caster. The designer of a part for die casting should work hand in hand with the die designer if the best possible results are to be realized. Often it is possible to redesign the part so as to simplify the die-casting operations and materially reduce the cost.

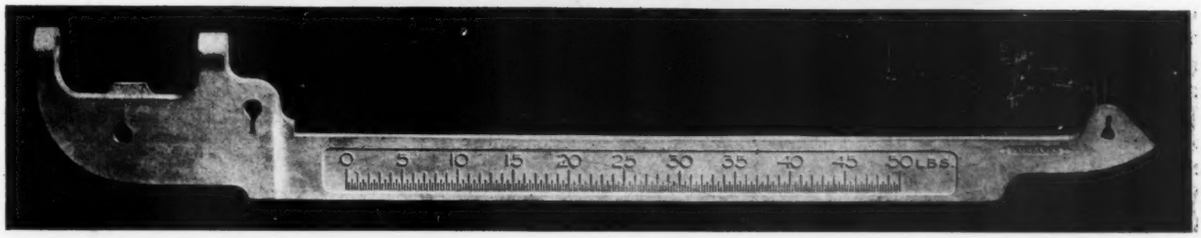
Where large quantities of simple or relatively small castings are desired, it is almost invariably advantageous to construct a die that will produce two or more castings at one time. Such a die is called a multiple or combination die depending on whether the castings produced in it are of the same or different designs. On the other hand, if the number of castings is limited, it is better to use a small die having but one impression. The gating, venting and coring of the casting also determine whether or not a multiple or combination die should be used.

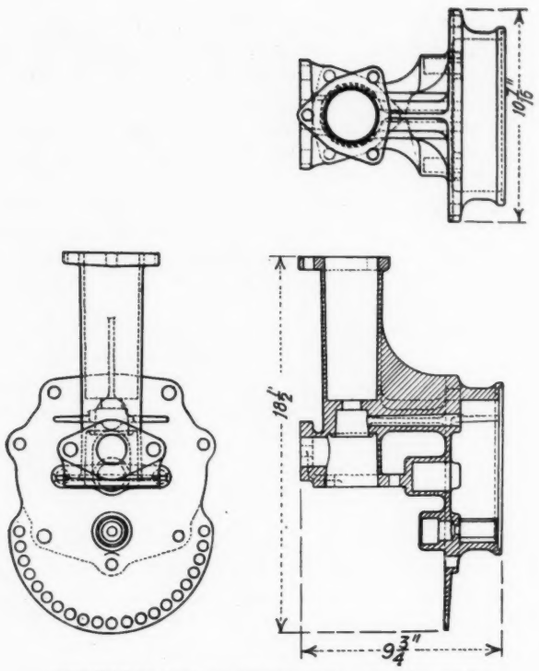
The orientation of the impression, or mold cavity, in

STEERING column bracket for a speed boat. Though the overall dimensions are 4x7x9 in., the weight is only 1.28 pounds

FRAME of a portable typewriter die cast to reduce amount of machining required and to obtain lightness and rigidity. Weight 1.25 pounds

DIE CASTINGS faithfully and accurately reproduce the finest engraving on the original model, as shown by this scale beam





DOMESTIC fuel oil burner part. In this casting are 43 holes cored in four different directions

the die depends upon the shape of the casting and the number of cores required. The die-halves open and close in but one direction, and the casting can only be removed in that direction. Any under-cuts or side projections which can not be brought to the parting line must be provided for by the motion of a part of the die in another direction, thus necessitating the use of a slide. Holes and cavities in the casting are taken care of by means of cores sliding back and forth along the line of the axis of the holes. This means that it may be necessary to withdraw the cores in several directions. One problem the die designer has is the placing of the casting in the die so that the number of auxiliary motions is reduced to a minimum. Undercuts on the interior of a casting are provided for by employing collapsible loose cores.

Wherever it is necessary to withdraw a core, or part of the die, from the casting during the production of the casting, draft or taper must be applied. For cores between $\frac{1}{8}$ and 1 in. in diameter, the desirable draft or taper is approximately 0.005 in. per $\frac{1}{4}$ in. of length. If the cores are less than $\frac{1}{8}$ in. in diameter, the necessary draft per unit of length increases rapidly as the diameter decreases. The taper on larger cores, or cores outside the pin class, is less than 0.005 in. per $\frac{1}{4}$ in. of length.

Because of the severe wear and tear on cores, and their tendency to spring or warp under the shock of casting, the permissible length of core pins depends upon their diameter. Cores less than $\frac{1}{4}$ in. in diameter can be unsupported for a length not greater than four times their diameter. This factor may be increased to eight for cores $\frac{1}{2}$ in. in diameter. It is possible to use longer core pins than here indicated; in fact it is frequently done, but at the penalty of more frequent repairs and replacements. This, however, is sometimes more economical than the individual drilling of each casting.

A means must also be provided for gating and venting the casting. In general, the total amount of gate should be held to the minimum necessary to fill the die cavity completely and uniformly. The gate should be so placed that it will not interfere with the ejection of the casting from the die. If possible, it should not enter the casting on a surface that is to be polished or highly finished. The vents are always located on the parting line of the die.

The gate and fins which are attached to the casting as it comes from the die-casting machine are, as a rule, broken off by hand or by tapping with a wooden mallet. Heavier gates are removed by means of a band saw or lathe. The first cleaning operation is generally supplemented by hand filing and grinding, although some castings are cleaned entirely by machine. Frequently this cleaning operation is followed by such simple machining operations as drilling, reaming, and tapping. It requires comparatively little extension of the normal cleaning equipment to provide for such special finishes as are produced by buffing, grinding, ball burnishing, acid dipping, painting, japanning and electroplating.

In the past the largest size of die casting which could be produced has been limited by the size of the machines available to accommodate the necessary dies. With the development of larger casting machines, the problems of die manufacture have also become a limiting factor. There are three sets of dimensions which control the size of die and other equipment necessary for the production of large castings. These are: (1) The size of the die plates; (2) the total projected area of mold impression, (3) the depth of the casting in a direction perpendicular to the parting line.

With the machines now in use, the size of the die blocks is limited to about 24 in. in width (or length) but may measure 40 in. or more in the other dimension. The size of the casting which can be produced in such a die block is approximately 4 in. to 6 in. less than this.

The hydrostatic pressure exerted against the two halves of the die by the liquid metal during the casting operation tends to force them apart. This pressure is effective over and area equal to the horizontally projected area of the casting impression plus the horizontally projected area of all gates, vents and passages into which the metal penetrates. The resultant total pressure tends to open up the die-halves and, if the total area is too large, may permanently stretch the frame.

THE depth of the casting is usually limited to approximately half the maximum draw, or distance by which the die-halves can be separated at the full opening of the machine. With possibly a few exceptions, the largest die-casting machines now in general use have a maximum draw of approximately 24 inches. From the limits thus imposed, the maximum dimensions for aluminum die castings can be considered 24x36x12 in., and the maximum weight approximately 20 pounds. However, no serious obstacles are known to exist that would prevent building of equipment to produce larger pieces.

One of the outstanding characteristics of the die-casting process is its ability to produce castings with thinner walls than are obtainable by any other casting process. Aluminum die castings of the largest size that the present equipment will permit have been produced with a uniform wall thickness of 0.110 in., while casting walls of an area exceeding six square inches have been made with a maximum thickness of 0.075 in. Commercial quantities of die castings have been produced in aluminum alloys with walls tapering from 0.037 in to 0.028 in.

Commercial accuracy generally calls for limits on aluminum die castings of plus or minus 0.0015 in. per inch of dimension. If necessary, it is possible to maintain much closer limits on dimensions of 3 in. or more after the actual shrinkage of the casting has been determined.

WORM GEAR DRIVES

By EARLE BUCKINGHAM

Associate Professor of Mechanical Measurements, Massachusetts Institute of Technology

Analysis of Helicoids Used in Their Design

In this second of a series of articles the author presents the equations for the curves of intersection between helicoidal surfaces and planes passing through axis of the helicoid. The method of analysis gives results to a degree of accuracy not attainable by laying out the profiles, and also presents a complete mathematical picture of the conditions.

✦

THE COMMON screw thread, helical gears and the hobs used to produce them, the relieved surfaces of a backed-off milling cutter, worm threads, and many other generated surfaces commonly found in the machine shop, are helicoidal surfaces. In order to make a complete and intelligent study of the action of a worm and worm gear, it is necessary that their helicoidal surfaces be analyzed.

The following analysis gives the equations of the curves of intersection between certain helicoidal surfaces and planes passing through the axis of the worm, and the equations of the tangents to those curves. Most of the helicoids analyzed here have straight-line generatrices. The five common types of helicoids are the convolute helicoid, the screw helicoid, the involute helicoid, the chased helicoid, and the milled helicoid. Only the last three of these types will be analyzed at this time.

The convolute helicoid, so called for want of a better name, is the surface that would be produced by setting a threading tool with a straight cutting edge, above or below center with the direction of inclination of the cutting edge or generatrix in the same general direction as the slope of the helix, when looking down upon the set up. Its generatrix is tangent to a cylinder concentric with the axis of the helicoid and of any diameter.

The screw helicoid is a limiting case of the convolute, wherein the generatrix passes through the axis of the helicoid, the diameter of the base cylinder being reduced to zero. This surface would be produced by setting a threading tool with straight cutting edges, at the level of the center line of the work.

Another particular form of the convolute is the involute helicoid. Its generatrix is tangent to a concentric cylinder of such diameter that the lead angle on the base cylinder is the same as the angle of the generatrix with a plane perpendicular to the axis. Thus the generatrix of this helicoid is a straight line continuation of the helix on the base cylinder. This helicoid is the form of an involute helical gear tooth surface.

The fourth helicoid is the same as the first except that the direction of the inclination of the generatrix is opposite to the direction of the slope of the helix of the thread. This is the form produced by a straight side threading tool tipped to the helix of the thread, and will therefore be called a chased helicoid.

The fifth helicoid is the form produced by the enveloping action of a cone-shaped milling cutter or grinding wheel, tipped to the helix of the thread. The generatrix in this case is not a straight line but a curved one, the shape of this curve depending upon the cone angle and diameter of the cutter as well as the lead and diameter of the helicoid. This will be called a milled helicoid.

We will now set up the necessary equations in order to be able to plot and study the curves of intersection between the various helicoids and a plane passing through the axis of the worm. The following notation will be used throughout this analysis of helicoidal sections, with additional symbols which will be listed as required.

L = lead of generatrix, or the distance it advances in an axial direction in one revolution of the helicoid.

α = angle between the generatrix and a plane perpendicular to the axis of the helicoid.

δ = angle between the tangent to the helix at radius r and a plane perpendicular to the axis, often called the lead angle.

ε = the angle of rotation of the generatrix.

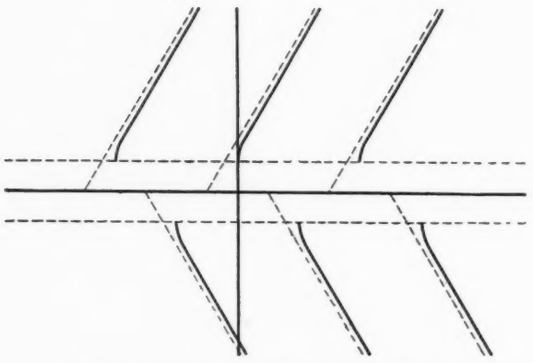
a = radius of the base cylinder to

which the generatrix is tangent.

D = distance from axis of helicoid to intersecting plane.

The involute helicoid, as defined before, is one whose base cylinder is of such diameter that the lead angle there is equal to the angle of the inclination of the generatrix.

The involute helicoid is probably the one most often used in machine shop practice. It can be formed in a great variety of ways. In fact, this involute helicoid has been patented over and over again as the form produced by different set-ups. It is the form of an involute helical gear as produced on a gear shaper or gear hobbing



INVOLUTE Helicoid, Axial Intersections

machine. It is also the form that results from hobbing a screw thread with an annular hob. It is also the form that results from rolling a screw thread either with annular or flat rolling dies. It is the form of hobs used for hobbing spur or helical involute gears as well as the form of the relieved surfaces of gear shaper cutters. This form is automatically generated whenever a cylindrical blank is rolled by or screwed past a flat forming surface.

The equation of the intersection curve of the involute helicoid with a plane that contains the axis is as follows:

$$x = \frac{L}{2\pi}\left[\frac{\sqrt{y^2 - a^2}}{a} - \arctan\frac{\sqrt{y^2 - a^2}}{a}\right] \quad (1)$$

The equation of the tangent to this intersection curve is as follows:

$$\tan\phi = \frac{dy}{dx} = \frac{2\pi ay}{L\sqrt{y^2 - a^2}} \quad (2)$$

The chased helicoid, as defined before, is the same as the convolute helicoid except that the generatrix is inclined in the opposite direction to that of the helix on the base cylinder.

The equation of the intersection curve of the chased helicoid with a plane that contains the axis is as follows:

$$x = \frac{L}{2\pi}\arctan\frac{\sqrt{y^2 - a^2}}{a} + \tan\gamma\sqrt{y^2 - a^2} \quad (3)$$

The equation of the tangent to this intersection curve is given by:

$$\tan\phi = \frac{dy}{dx} = \frac{2\pi y\sqrt{y^2 - a^2}}{aL + 2\pi y^2\tan\gamma} \quad (4)$$

When a threading tool with a flat cutting face is set at an angle and used to chase the threads, we have a definite relationship between the various factors involved as follows:

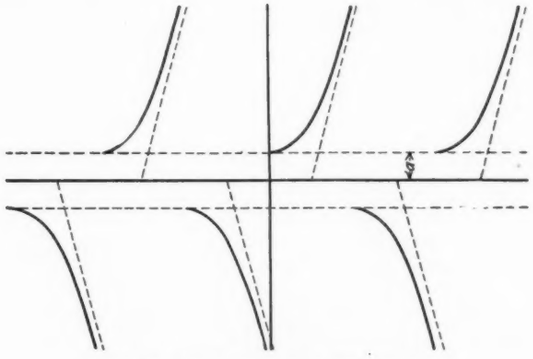
When β = angular setting of threading tool
α = half included angle of threading tool
A = distance between sharp point of threading tool and axis of the helicoid
γ = inclination of generatrix
a = radius of base cylinder.

Then
$$a = \frac{A\tan\alpha\sin\beta}{\sqrt{1 + \tan^2\alpha\sin^2\beta}} \quad (5)$$

$$\tan\gamma = \frac{\tan\alpha\cos\beta}{\sqrt{1 + \tan^2\alpha\sin^2\beta}} \quad (6)$$

It has long been known that the form of a thread produced by milling or grinding with a cone-shaped milling cutter or grinding wheel varies from that produced by a lathe tool. The term "milled helicoid" in this analysis includes all worm threads produced by cone-shaped milling cutters or grinding wheels. The thread forms on such worms are the result of the enveloping action of the generating cone about the axis of the worm as the worm is screwed past the cone-shaped cutter or wheel. The resulting thread form in an axial section may be concave, convex or a form of double curvature, depending upon the relative diameters of worm and generating cone, angle of cone, angular setting of cone, lead of worm, and other similar factors.

THE inter-relations between these several factors are so complex that no single equation has yet been developed to give directly the relation between the two co-ordinates of the thread form. Therefore a series of equations must be solved first to establish such a relationship of the co-ordinates of the axial section of the thread form, and then these related values are used in all succeeding equations. The following equations enable



CHASED Helicoid, Axial Intersections

the co-ordinate of the intersection curve of the milled helicoid with a plane that contains the axis to be determined. The notation is as follows:

L = lead of worm
C = shortest distance between axes of worm and generating cone
β = angular setting of axis of generating cone with axis of worm
α = angle of generating cone (half the included angle of the cutting edge of a milling cutter or grinding wheel)
R = radius of generating cone at point where projection of axis of generating cone on plane containing axis of worm intersects the worm axis (this radius is usually the radius to the intersection of the two generating cones on a thread milling cutter)

b = distance between axis of generating cone and arbitrary intersecting planes

x, y = co-ordinates of milled thread form on intersecting plane that contains the axis of the worm.

The equations required to determine the co-ordinates of the intersection curve of the milled helicoid with the plane that contains the axis of the helicoid are as follows:

$$Y = \frac{D\sqrt{F^2 + (E^2 - D^2)} - EF}{E^2 - D^2} \quad (7)$$

where $D = L - 2\pi C \tan\beta + 2\pi b \tan\beta(1 + \tan^2\alpha)$

$E = \tan\alpha(L \tan\beta + 2\pi C)$

$F = 2\pi R \tan^2\alpha \tan\beta$

$$R' = b\sqrt{Y^2 + 1} \quad (8)$$

$$\tan\Delta = \frac{bY\cos\beta + (R - R')\tan\alpha\sin\beta}{C - b} \quad (9)$$

$$y = \frac{C - b}{\cos\Delta} \quad (10)$$

$$x = (R - R')\tan\alpha\cos\beta - bY\sin\beta + \Delta L/2\pi \quad (11)$$

The foregoing equations must be solved in the order given to determine the co-ordinates of the thread form for the axial section. The factors L, C, α, β, and R are constant for any given example, while different values of b are selected which will cover the depth of the thread.

The equation of the tangent to this thread form, the angle of this tangent being measured from the axis of the helicoid, is as follows:

$$\tan\phi = \frac{(b/\cos\Delta) - \sin\Delta\ (b\tan\Delta - H}{R'\tan\alpha\cos\beta + bY\sin\beta - K(b\tan\Delta - H)} \quad (12)$$

where $H = R\tan\alpha\sin\beta + y\sin\Delta$

and $K = (L/2\pi y)\cos\Delta$

As a definite example, and also to investigate the influence of a change in diameter of the cutter on the form of the thread produced, the co-ordinates and tangents of the thread form will be calculated for:

Six thread worm
8.625 in. lead of worm
1.437 in. pitch of worm
27° half included angle of thread milling cutter
41° 45′ angular setting of cutter
3.077 in. pitch diameter
3.759 in. outside diameter
2.287 in. root diameter.

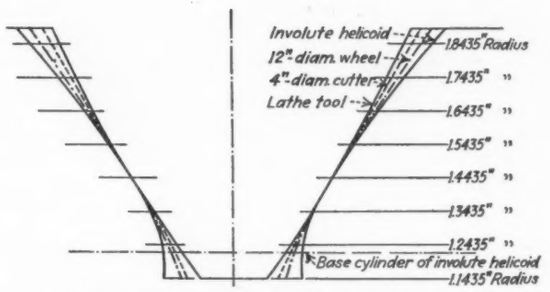
The forms of the axial section of this worm will be determined when produced by a 4-in. diameter milling cutter and a 12-in. diameter grinding wheel. The diameters of these cone-shaped cutters to the intersection of the two cones, if they were extended to meet in a sharp corner, would be about 0.260 in. larger than their actual diameters. The distance between the axis of the worm and the axis of the cutter will be about 1.0135 in. greater than the radius of the cutter to the sharp corner. This will give the following values for the solution of the above equations 7 to 12:

	4-in. cutter	12-in. wheel
L =	8.625	8.625
C =	3.1435	7.1435
β =	41° 45′	41° 45′
α =	27°	27°
R =	2.130	6.130

With the 4-inch cutter and the following values of b, we obtain the following co-ordinates and tangents for the form of the axial section:

b	2.0000	1.9000	1.8000	1.7000	1.6000	1.5000	1.4000	1.3000
y	1.1723	1.2612	1.3452	1.4500	1.5474	1.6460	1.7452	1.8448
x	0.1482	0.1935	0.2452	0.3012	0.3596	0.4191	0.4786	0.5373
$\tan\phi$	2.0940	1.8642	1.7441	1.6837	1.6592	1.6596	1.6783	1.7124

The inspection of the values of the tangents to this form shows the curvature to be convex at the lower part from the root to above the pitch line and then changes



MILLED and Chased Helicoid, Axial Intersections

to concave near the tip, because these values decrease until just above the pitch line and then start to increase again near the tip.

With the 12-in. grinding wheel and the following values of b we obtain the following co-ordinates and tangents for the axial section:

b	6.0000	5.9000	5.8000	5.7000	5.6000	5.5000	5.4000	5.3000
y	1.2054	1.2777	1.3595	1.4493	1.5444	1.6436	1.7457	1.8499
x	0.1782	0.2084	0.2496	0.3009	0.3600	0.4254	0.4955	0.5690
$\tan\phi$	2.7491	2.1592	1.8453	1.6696	1.5561	1.4826	1.4348	1.4043

The decreasing values of the tangents from the root to the tip show that this thread form is convex over its entire profile.

THE co-ordinates of the two foregoing thread forms are not directly comparable because of the different values of y. We shall therefore interpolate to obtain values of x for common values of y by dividing the difference in the value of y by the value of $\tan\phi$ and adding this correction to the value of x. This interpolation will not be absolutely correct, but the error will be very slight and the resulting comparisons will be sufficiently accurate for all practical purposes. Using the following common values of y, we thus obtain the following tabulated corrected values of x for these two profiles:

y	1.143	1.243	1.343	1.443	1.543	1.643	1.743	1.843
	4-inch diameter milling cutter							
x	0.134	0.184	0.239	0.297	0.357	0.417	0.477	0.536
	12-inch diameter grinding wheel							
x	0.155	0.192	0.240	0.297	0.359	0.425	0.494	0.564

It is apparent from a comparison of these values of x that the larger wheel removes more metal from the top and the bottom of the thread profile than does the smaller cutter, while the two forms are of practically the same width near the middle of the thread form. Before plotting these profiles we will determine the co-ordinates of the two limiting conditions on either side of these profiles; namely, those of an involute helicoid which would represent the conditions when a wheel of infinite diameter is used and the side-cutting at the top and the bottom of the thread profile would be at a maximum, and those of the chased helicoid where there is no side-cutting action present.

For the involute helicoid we have the following factors:

$$L = 8.625$$
$$\alpha = 27°$$
$$\beta = 41°45' \text{ (angular setting of rack)}$$
$$\cos \gamma = \cos \alpha \cos \beta$$
$$\text{whence } \cos \gamma = 0.66475$$
$$\gamma = 48°\ 20' \text{ inclination of the generatrix to a plane perpendicular to the axis of the helicoid.}$$

$$a = \frac{L}{2\pi \tan \gamma} = 1.22145 \text{ radius of base cylinder}$$

These values used in equations 1 and 2 give the following:

y	1.1435	1.2435	1.3435	1.4435	1.5435	1.6435	1.7435	1.8435
x	Fillet	0.2083	0.2444	0.2982	0.3628	0.4349	0.5127	0.5949
$\tan\phi$	.....	4.7458	2.1366	1.6697	1.4554	1.3299	1.2469	1.1879

The foregoing values of x have all been corrected by the amount of +0.20525 to make them directly comparable with the previous values.

For the chased helicoid we have the following factors:

$$L = 8.625$$
$$\alpha = 27°$$
$$\beta = 41°45'$$
$$A = 1.0135$$

From equation 5 we obtain $a = 0.32563$
From equation 6 we obtain $\tan \gamma = 0.35998$
And from equations 3 and 4 we obtain the following:

y	1.1435	1.2435	1.3435	1.4435	1.5435	1.6435	1.7435	1.8435
x	0.1017	0.1718	0.2369	0.2974	0.3548	0.4096	0.4622	0.5129
$\tan\phi$	1.3658	1.4869	1.5971	1.6957	1.7850	1.8653	1.9375	2.0025

The foregoing values of x have been corrected by the amount of —2.05274 to make them directly comparable to the previous values.

THE forms of these axial sections are plotted in the above figure, showing the nature of the side-cutting action of the milling cutter or grinding wheel. The larger the diameter of the cutter, the greater this side-cutting will be.

The example shown here has a large lead angle. A decrease in the lead angle will decrease the amount of this side-cutting and thus produce a thread form more nearly approaching a straight line. A decrease in the angle of the thread, on the other hand, will increase the amount of the side-cutting and thus increase the curvature of the thread form.

It will be noted that the forms shown in Fig. 3 vary on both sides of a straight line. In other words, a straight-line profile, or that of the screw helicoid, is approximately the average of all these forms. For purposes of general analysis, therefore, the screw helicoid may be used, which will give a reasonably close approximation to the contact conditions present on other types of helicoids of similar characteristics such as lead, diameter and thread angle. In specific cases, however, where the worm is used in an important or critical drive, the actual type of helicoid produced by the manufacturing process employed should be analyzed.

By the use of the above equations, together with other relationships which will be established, the conjugate tooth action between a worm and its gear may be analyzed analytically without the necessity of making geometric layouts. By the analytical method, the individual sections of the tooth profiles and the action of the teeth of the worm and gear may be studied in detail and the contact conditions over the face of the worm gear may be ascertained.

Rivet Head Failures

By Paul B. Swinton

PASSING through a tank shop, I noticed several rivets whose heads had snapped off at the shank. Some weeks later I met Carson and mentioned the fact to him, as he was engaged in experimental work on riveted joints.

"It's the original manufactured head that pops off," grumbled Carson. "As long as rivet manufacturers continue to put square corners under the head, and people keep on using such rivets, the heads will pop off occasionally."

"You'll have to explain that to me," I said, noting that Carson seemed touchy on this subject "What has been your experience along this line?"

"Once, while driving $\frac{1}{4}$-in. cold rivets," Carson replied, "the heads flew off while the riveters were still working on the job. There was the usual pow-wow and we decided the rivets were too hard, so we changed to softer rivet steel and the trouble disappeared.

"Recently I ran into the same trouble, on $\frac{7}{8}$-in. hot-driven rivets. The rivet joint was subjected to considerable shock and vibration, and failure did not occur until after the machine had been put in service. That led me to make some experiments which showed that the fundamental cause of these failures is the square corner under the manufactured head of the rivet.

"The reason for it is really very simple. When a rivet is driven its shank swells to fill the hole, except at the section where the shank joins the head. With an oversize hole, a portion of the head is even forced into it. In any case, a sharp corner or crease is formed where the shank joins the head. Stresses concentrate at that point. If these stresses are beyond the endurance limit of the material, and are repeated, as in vibrations set up by rivet hammers, a fatigue fracture occurs. In the first case I mentioned, the trouble disappeared because the softer material we changed to, being more yielding, did not readily permit large stress concentrations.

"Fortunately, such failures rarely occur except when the rivet hole is appreciably oversize and the rivets are machine driven. The great pressure results in deep sharp creases, hence large stress concentrations. But in the case of hard alloy-steel rivets failure will always occur unless a generous fillet is put under the head of the rivet. I know a case where they built a tank using chrome-steel plates and rivets. The rivet heads popped off as fast as they were driven, because the steel was air hardening. They then made rivets with a fillet under the head, and that cured the trouble."

"Thanks for the explanation," I said. "I would never have guessed that to be the cause of rivet heads popping off. Yet I don't see why putting a fillet under the head helps any."

"You're like the rest of 'em," exploded Carson, "no one wants to believe it. The fillet simply prevents the formation of a crease or sharp corner. I will show you longitudinal sections cut from tested rivets."

Later Carson showed me his beautiful sectioned and etched test specimens with fine hair-like fractures extending in from a crease under the head of those rivets that had no fillets. Seeing is believing. Carson is right. "Uneasy lies the head" applies also to rivets, if they have no fillets.

COMMUNITY RESEARCH IN JAPAN

By FRED H. COLVIN

Consulting Editor

JAPAN, as has been said many times before, is the land of contrasts, where customs and arts that have been practised for a thousand years rub elbows with the most modern ideas. With a few notable exceptions business is done in small shops rather than in large factories, much of the work being in two or three man establishments. Every effort is being made to improve their methods and output, and with this in view, some cities are encouraging manufacturers by operating municipal research laboratories where the many problems of industry can be studied.

A good example of this is found in Kyoto, where the laboratory shown in the accompanying illustration is under the able guidance of T. Nakai. As can be seen, the building is of modern and attractive construction. It contains many laboratory workrooms, in each of which some specific questions are studied.

Although perhaps the majority of the time is spent on researches in the textile field, other lines of industry are presenting problems and are having them studied in this laboratory. Chromium plating is one of many subjects receiving attention. One of the pictures shows the laboratory for electro-chemical research. The artistic use of electroplating is being studied.

The laboratory aims to aid in building up the various industries of the city by studying any research problems that are presented. The results of the investigations are for the benefit of all of the manufacturers of Kyoto, the purpose being to build up the whole community rather than any one firm. The idea might well serve in many communities here.

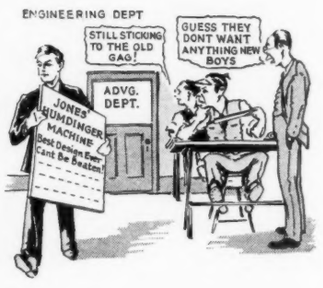
THE ENGINEERING

The scene is a big contract production shop, consolidated also with an iron foundry and a nonferrous metal plant. It controls, also, a smaller shop that makes a specialty of contract production for the chain stores and mail-order houses. Conferences of the engineering and affected production executives with the chief engineer have grown into what the plant calls "The Engineering Council," which meets in a "council room" in the engineering department. Foremen are called in, and others drop

Shall Past Advertising Control Development?

"WHAT'S got under your skin this morning, Ray?" asked the even-tempered G. M., Howard Hedley, addressing his aggressive sales manager as he opened the weekly meet. "You look about ready to explode."

"Well, it wouldn't take much more to make me," responded Ray. "Here we've spent a cold $100,000 in advertising our pet type of construction, with a few knocks, by inference at least, at competing products, and now Art Levering wants to upset the whole applecart by adopting the very things we've poohpoohed. Maybe he's got good engineering reasons, but he had 'em for the construction we've been using, too."


ENGINEERING DEPT
STILL STICKING TO THE OLD GAG!
GUESS THEY DONT WANT ANYTHING NEW BOYS
ADVG. DEPT.
JONES' HUMDINGER MACHINE Best Design Ever Cant Be Beaten!

"Art generally has good reasons for his suggestions, Ray. They do not always control our policy, however, if other considerations outweigh them. Let's hear his ideas, anyway."

"I dislike alibis," replied Art, "but it's necessary to explain some reasons for past history to get a clear picture of the present situation. Every engineering product has its advantages and disadvantages, and what seems an advantage today may be a drawback two years hence. That's true, of course, in other concerns besides our own. When we adopted our present construction, welding, for example, had not been developed to anything like its present degree of perfection. The type of riveted joints we used was the best we knew anything about at that time. Wood framework had several disadvantages and we decided to drop it in favor of all-metal construction which seemed most promising and gave us strong talking points. Too strong, I fear, for we boosted it sky high in our advertising. It gave us a big advantage for a time and we made the most of it, as you all know.

"In the meantime conditions changed. Many of the disadvantages of wood have been overcome, and the combination of wood and metal gives some very real advantages. Our die cost is heavy and tends to make the quick changes brought about by changing styles too expensive. A composite structure built up with some welded parts and some wood, will put us on even terms with competitors and give us a product at least as good as our present one."

"Yes, and force us to re-educate our salesmen, as well as the public, in our advertising," chimed in Roy Sellers.

"It will mean a lot of new equipment in the shop, too," added the super. "Still, what we have now hasn't been kept half as busy as it was once."

"That's true, George, and I get Roy's point of view, but Art's arguments have to be considered, too. Our plant must keep its share of the business, even if we have to swallow some things we've said in print. Guess we'd better soft pedal on committing ourselves to any one type of construction after this."

Should over-enthusiastic sales arguments be allowed to handicap engineering development? What is the best policy from the designer's point of view? Replies, preferably based upon specific experience of engineers, will be welcomed and paid for if published.

COUNCIL

in. The problems are not solved for the readers, but some of the opposing opinions are brought out. Engineers and designers are invited to discuss the problem, or to present new problems for discussion. Acceptable letters are paid for at regular rates.

DISCUSSION
OF COUNCIL TOPICS

Getting Action on Standards

THE article in your January issue, relative to standardization of motor dimensions, is very interesting to us. It so happens that, at the present time, we are faced with a problem on this same subject. The motor company from whom we had obtained our motor supply for automatic water systems, which we manufacture, recently sold out to a larger company. The new owners now approach us with the idea of getting our business in motors which are standard with them rather than with the old company.

In checking through this line of motors, we find that motor base dimensions, shaft height, and shaft extensions are entirely different from the old line. If we are to accept this line of motors, it means that we will have to make a number of pattern and jig changes to accommodate the new dimensions. This will mean a considerable expense to us, in addition to confusing us on the matter of replacing motors on pumps already in service.

We have turned to other lines of motors, and find that we can do little better, as far as motor dimensions are concerned.

Therefore, you can readily appreciate that any move towards standardizing motor dimensions, particularly in the small sizes, ⅛, ⅓, ½, ¾, 1, and 1½ hp., will receive the hearty co-operation of all of us.

—THOMAS B. CLARK, *Chief Engineer, Ward-Love Pump Corporation.*

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Who Should Design Patterns?

THE general procedure followed by one company is as follows:

On ordinary designs of experimental machinery, or of special parts that are wanted quickly and of which few are likely to be required, the engineering department first designs the castings to accomplish the results desired from an engineering standpoint, with regard to strength, purpose, or function of the parts in relation to the machine, and with all possible consideration given to the production of these castings in the foundry, to the machine work involved, and to the assembling and dismantling of the machine.

On standard parts of machines which are to be made on a large production scale, the design is gone over carefully both from a foundry and from a machine shop production viewpoint before the patterns are built and suggestions or criticisms are entertained and considered in order to avoid any foundry or machine shop complications which might increase the cost of production.

Very often slight changes of design, quite satisfactory from an engineering viewpoint, can be accomplished to avoid difficulty, and to reduce production costs considerably. This reduces the "grief" which might be encountered if the design were left entirely to the engineering department, without giving the foundry and machine shop an opportunity to make suggestions until after the patterns were made and production started.

—J. M. ALLEN.

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Do You Still "Roll Your Own"?

WHEN designing machinery it is of course only common sense to specify in so far as possible standardized parts such as bolts, oiling devices, bearings, couplings, and similar articles. Such parts should also be purchased from concerns which concentrate all their efforts on these particular things.

But the designer often meets an obstacle in attempting to adapt his design to specialized parts. Many drafting rooms do not have readily available a complete file of catalogs covering the standardized parts applying to their field of work. The number of catalogs at the disposal of the engineers and draftsmen are often very meager, usually the personal property of one of the men, and possibly out of date.

My opinion is that a modern engineering department should be supplied with a catalog file which contains the latest editions of all catalogs that may be of interest to the designers. Several copies of such catalogs which are frequently in demand should be on hand in order to avoid the time consuming and annoying necessity of having to wait for a copy. This catalog file should be kept up to date by a reliable person specially assigned to this job. He should keep an index of the catalogs as to number, firm name and product, so that any desired information can be procured speedily.

In this connection it is to be deplored that manufacturers have so far been unable to agree on a standard size of catalog. There are small and thick catalogs and large and thin ones. However, the various sizes can be kept on separate shelves although this complicates the filing operations.

The psychological moment in supplying sufficient and quick information to the designer is very important. Nobody likes to bother his fellow workers or supervisors, or go to other departments in order to secure information that should be available without any trouble. This data he can get if catalogs are available.

The designer's mind is distracted from his work if he is hunting or waiting for a catalog, and therefore he is often tempted to make a design which disregards specialized products altogether.

—WILLIAM BRASACK, *Mechanical Engineer.*

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Developing New Products

IDEAS to be developed must be put into some tangible form such as blueprints and specifications. For this reason, that should be the first step. There are then two phases to be considered, namely, the consumer and the producer of the article to be developed. Under the first group there are the sales managers, the salesmen, the service department and the user. Under the second group we have the chief engineer, works manager, rate fixer, experimental shop organization, production foreman, mechanics and others. It is important that the feasibility of developing new products be discussed by representatives of all of these departments. At this conference, which will be preliminary, it should be decided whether the article or idea is worth considering. An average of 90 per cent of the suggestions will be thrown out as being unfeasible.

Assuming that the idea is to be further developed, a questionaire should be sent to everyone concerned in order to obtain the pros and cons as regards the problems. The results of this questionaire will finally determine whether or not development is to be entered into. Assuming the development is to be prosecuted a draftsman should be delegated to make drawings in order that a model

can be made. The draftsman should be familiar first with the article to be eventually manufactured. The model is then made in the experimental department, which may be a specially equipped department for the production of models only, or may merely make use of machines and bench space in the toolroom or other part of the plant. In some cases it may require that the model be made by an outside firm.

Upon completion of the model it should be examined very closely by all concerned. The proposed machine after being fairly criticized will then be redesigned. This last design must take into consideration all available patterns and tool equipment. Throughout this whole program the development of the new product should be placed in the hands of one person only.

—D. M. MILLER, *Huddersfield, England.*

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Do You Still "Roll Your Own?"

STANDARDIZATION has done much for manufacturers working on a production basis. Of course, while a part is still in the experimental stage, the details should be developed in the design department and possibly manufactured in the shop, but after the part has proved to be successful and the company goes in for production, there should be suggestions to purchase substitutions such as bolts, nuts, washers, rivets, etc., from specialists who no doubt can supply the parts much cheaper. The chief engineer should refer such substitutions to the designers for a check as to fits, tolerances, and strength. Such a system has two distinct advantages: First, the purchase of parts from a specialist by several manufacturers establishes the parts as standards and reduces the cost of such parts with the more general use; secondly, it will help the sales department inasmuch as a prospective customer can be shown that parts may be replaced easily because they are standard.

MORTON SCHWAM, *Design Draftsman, Naval Aircraft Factory, Philadelphia.*

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Developing New Products

ONE OF THE FIRST considerations governing the establishment of a separate experimental or research department is the size of the factory and the probable amount of such development work to be required. Another factor to be considered is whether such work is to be conducted the year around or purely seasonally. The factor of interrupting production to carry on experimental work is more easily decided —where production is seasonal the plant can be utilized for research during the "off" months, with the advantage of avoiding useless overhead and of keeping the men employed during these months. This plan is particularly advantageous where research work can be completed in a fraction of the year, although, here, the question enters, "Would it not be cheaper to have the work done outside?"

Past experience dictates that, where experimentation is a year-long necessity, a separate, complete unit must be established for the purpose. • If this were not so, the big automobile companies would not have invested millions of dollars purely for research development. It is necessary that such large-scale development work come under one man who will be held responsible for results achieved and who has no connection with production requirements. Even so, he cannot realize his mission fully unless given a separate division equipped for his purposes and divorced from any production connection.

The basic principle of segregating new development work from production holds good no matter what the size of the plant may be. However, accompanying factors necessitating experimental work in connection with production are sometimes of a nature prohibiting separation of the two activities as much as might otherwise be desired.

—E. R. SHIELDS, *Processor, Oakland Motor Car Company.*

■

Who Should Design Patterns?

PERHAPS it would be of interest to hear on this topic from one who has the fundamental knowledge of foundry practice and patternmaking and has learned the trades, as stated in the January issue by Mr. Cornelius.

Patterns to produce satisfactory sound castings must be designed to suit conditions of foundry where castings are to be produced. Very often the designing of castings is confused with designing of patterns. The latter can be successfully settled only by one thoroughly acquainted with the trade. The question of filling in a boss or pad to overcome underdraft or a sand pocket, the change from cope to drag to eliminate shrink and strain in heavy sections on light structures, or the use of chills or cores for the excess metal, the alteration of a rib, boss, or web to overcome costly cores, proper draft and parting for deep lifts, and other complications too numerous to mention can be seen quickly and efficiently by a competent patternmaker. While changes may insure easy practical molding and good castings, sometimes also they produce a poorly designed casting causing interference of other parts, or they will be stressed where load is greatest, or make the set up for machining difficult. In all the last considerations the patternmaker holds no interest, unless he has knowledge of machining and is familiar with the designed product.

It is my experience that such conditions can be settled best by one who has acquired sufficient knowledge in the trades concerned and can apply it on the board in designing. The use of such experience is a saving in the original cost of design, and in production thereafter. It saves a compromise on differences of opinions. Most always it is the small details that have caused the failure in the design and success in that of competitors.

—HENRY F. J. SKARBEK, *Designer, New Standard Aircraft Corporation.*

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Getting Action on Standards

EXPERIENCE in designing special machine equipment has impressed upon me the utter absurdity of the present situation with respect to the lack of standard mounting dimensions for electric motors. This has been particularly noticeable to me, since the major part of my design experience has been in the aeronautical field, where standardization has been so extensively and successfully applied that it is literally taken for granted.

Standardization is not neary so difficult of accomplishment as most people believe. If the machinery industry has no established standardizing agency an appeal to the United States Department of Commerce for assistance would get attention. This department has been carrying on a wonderful work of simplification during the past few years. It never attempts to thrust standards upon an industry, but would use its experience and facilities to guide the machine and motor industry in formulating standards if requested to do so.

The success of a standard depends upon its inherent advantages. If properly established through co-operation of those most concerned it will endure. Changes are not difficult to effect when occasion requires them.

—LEWIS J. YAPP, *Design Draftsman. Naval Aircraft Factory, Philadelphia.*

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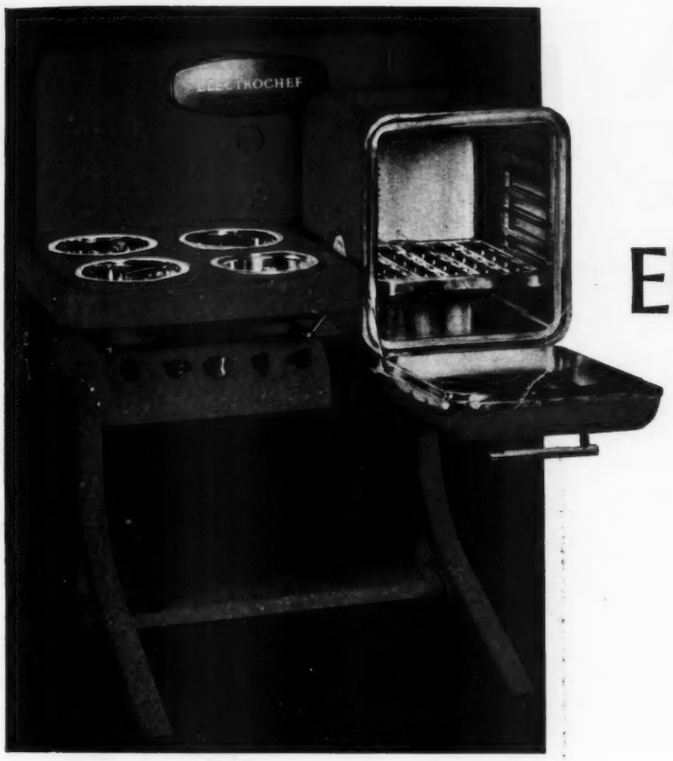
Do You Still Roll Your Own?

IN LINE with the development of specialization in all industry, the manufacture of small parts, such as bolts, screws, and nuts, has become a definite field for a shop equipped solely for that class of work, with a resulting lowering of unit cost. It is, of course, a source of considerable pride to know that a completed machine was made "from soup to nuts" in one shop, but it is extremely doubtful if many purchasers can be found who will pay a premium just to see the builder's pride justified. A machine without a buyer because of its price is hardly a source of pride to the builder, even though he did make it complete in his own shop.

—EUGENE OGDEN.



The ELECTROCHEF

+ A STUDY IN PRODUCT DEVELOPMENT

By WARREN NOBLE

Chief Engineer, Electromaster, Inc.

DURING the period of the initial expansion of the electrical industry, the makers of electrical apparatus were enthusiastic about lighting and power equipment, but were decidedly lukewarm when it came to developing apparatus for heating in the home. Electric heat on such a small scale as would be required for household use was inefficient and the cost thereof too high, they said.

However, as time went on, in those districts where hydro-electric power produced current of unprecedented cheapness, electric cook stoves, in spite of their high first cost and expense of operation, began to be used. Another drawback in these stoves was their slowness, that is, the relatively long time elapsing after the current was turned on before the stove had become heated to its operating temperature.

Last year less than 500,000 electric ranges were in use in this country. On the basis of their experience with these ranges, housewives praise their cleanliness and say that after one gets used to them, their cooking qualities are found to be good. But they complain that the electric ranges are slow for everyday use, and that their cost of operation is too high.

A certain public utility manager decided to investigate for himself the possibility of developing a cheap and economical electric range designed solely for using electricity as the source of heat, and taking advantage of all the peculiar characteristics of electric heat. In order to make sure that the fog of usage did not obscure the view, he hunted for an agent with a completely unbiased and, as far as possible, uninformed mind upon the subject of electric ranges in particular and cooking stoves in general. Having found such a person, he proceeded to lay down the outlines of an ideal specification based upon performance. He wanted something fast. He wanted something cheap to produce and economical to distribute, capable of being serviced by the customer, and last, but not least, it must be a better cooking machine. Having appropriated the necessary funds, stated his requirements, and told the engineers to "go to it and keep going," he sat back and watched for results.

A range committee was set up whose duty it was to study the construction, operation, performance and installation of existing ranges. This committee did a great deal of constructive work. The laboratory, in the meantime, began to collect data on actual performance.

FROM the facts they discovered, it was evident that if anything were to be done, a start would have to be made from first principles and the work carried on without regard for precedent. To spend time on design and production problems prior to the acquisition of a more efficient heating element was obviously a useless expenditure. It was equally futile to sit around and yearn for more heat units from a kilowatt hour than the Creator had originally decreed. So, if the requirement of speed was to be satisfied something had to be done to utilize more of the available heat.

The heating units of commerce showed extraordinary discrepancy between the masses of active and inactive material. In practically all of them the ratio of inactive to active ingredients was in excess of ten to one. Before any useful work could be done by such an element, it was necessary for the temperature of the entire mass to be raised; time was wasted because usually more than half the heat generated was devoted to making a "hot brick"

on which to cook. Usually, too, the "brick" weighed more than the cooking pot and contents! Our first effort, therefore, was to see how much reduction could be made in the "dead" material surrounding the active heating element. To this end, the ideality of a design that dissociated the refractory from the mechanical load of the cooking operation looked promising. The desirablility of using a reflector as a means of concentrating the heat, followed naturally.

The reflecting type of heating unit was a well-known commercial article and the principle was sound, but all such devices in common practice used low power elements with reflectors of large area and were operated at low temperatures. Using a reflector with a high temperature nucleus was distinctly another story. In the first place, no cook would trouble to repolish reflectors that tarnished every time they were used, nor was there any material in common use capable of withstanding the arduous conditions without immediately tarnishing to an extent that greatly decreased the reflecting power. However, so great were the benefits to be derived from a workable reflector that vigorous pursuit was deemed worth while and chromium plating came in for discussion.

CHROMIUM plating as practiced for ornamental purposes is done after first nickel plating either direct on the metal, if it be brass or copper, or upon a groundwork of copper plate if the base is steel. Usually the chromium coating is very thin. It was quickly learned that a plated surface of this type had no permanence for the simple reason that the chromium coating was discontinuous and that oxidation proceeded apace on the sub-surface of nickel. It became necessary, therefore, to plate chromium directly on the steel and while the deposition of chromium on steel was itself no new thing, its application to this particular problem proved to be one of those jobs that seemed almost hopeless of accomplishment. Eventually a way was found to do it, not only successfully from the performance standpoint, but commercially at an unprecedentedly low cost. Moreover, as an aftermath of the struggle, a plating plant was developed which avoided the necessity for the operators' "make-up" common to plating rooms, and above all, this plating unit could be spotted in a production line exactly as a machine tool or press may be located.

With this problem solved, serious attention to the light weight heating element and its application was in order. A simple conical form of heating unit, using helicoidal grooves molded in the refractory to support the nickel chromium alloy wire, presented a most advantageous assembly. The development of a triple contact socket followed, and the screwing in of the complete element, utilizing the center bolt as the neutral conductor, meets for the time being, at any rate, the requirement of ease of replacement. Everybody knows how to change a lamp bulb. Why teach them any new tricks?

Having progressed this far with a potentially satisfactory reflector and a potentially satisfactory form of heating element, there began the inevitable rehash of detail. The next necessity was to learn how to make such elements outside of the experimental room. Adventures in this direction constitute a history in themselves. Suffice it to say that after a great deal of fussing and the usual number of false starts, the development engineers found out how to make satisfactory welds, how to build with the proper allowances for expansion, how to mold the separate parts and how to make the complete assembly at a reasonable cost.

THE HEATING UNITS may be taken out and replaced as readily as an ordinary electric lamp

Throughout this period of development dozens of such elements were enclosed in double reflectors in order to carry on concurrently heating element and reflector life tests. Many times when we thought we had solved our problem, a batch of reflectors would go bad, and then the laboratory staff had to go back on a further investigation of the plating process. When the reflectors stood up, the electrical heating elements went bad, and so for months went the seesaw on the verge of a useful combination but without certainty that they could be produced under commercial conditions.

THIS uncertainty has gone. There stands developed today a heating element ready to give its full heat sixty seconds after the current is turned on, responsive to command with extraordinary rapidity, cheap to manufacture, and replaceable by any one capable of changing an ordinary incandescent lamp. Reflectors that retain their brilliancy are in production.

By this time, certain fundamentals for a good oven had firmly established themselves. All the electric ovens tested were good; much more efficient, in fact, than their general layout would lead one to expect. Again the problem of speed was tied up with the mass of the bricks surrounding the hot coils plus the fact that substantially all of the ovens utilized a heavy insulating jacket of rock wool or some similar means of avoiding excessive heat loss. No attempt seemed to have been made in any oven to secure internal circulation and inasmuch as it was obviously desirable to make an oven capable of broiling as well as baking, circulation appeared almost essential.

In the course of developing a new oven someone came through with the happy thought that a burner or heater might be located midway in the oven in such a way as to

give space for broiling beneath it and baking room above it. This proved to be the answer to the major problem in the design of the oven. By using a grid-type of heating element construction, it was possible to cut the dead material almost to the disappearing point, and the structure surrounding the hot coils became in effect a set of shallow flues.

BY THIS time the chromium plating experiments had progressed to a point where the plating of the entire inside of the oven was justifiably contemplated. It was evident that, if this could be done, the rust protection puzzle would be solved and cleaning the oven would become far easier than was theretofore possible in any oven. There was much theorizing on the probable cooking properties of a receptacle having walls of high reflective value. Then, for experimental purposes one was made. After testing it, everyone was convinced that they could never be satisfied with an oven lacking a single one of its qualities. More might be possible, but less could not be contemplated. The most difficult cooking operations assumed a clean-cut simplicity, and new standards of time and cooking quality showed up from every direction.

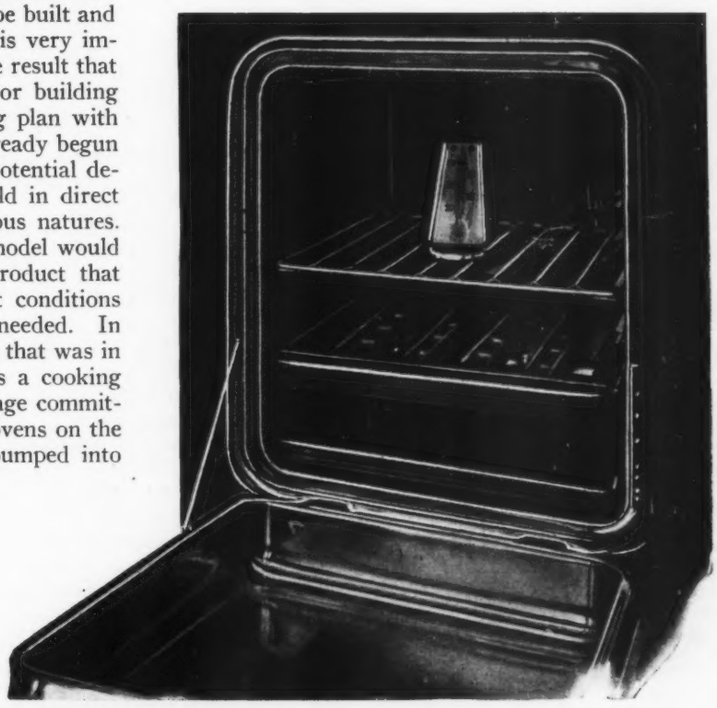
Progress toward an oven that would come to temperature in a hurry seemed to be most easily accomplished by getting rid of the conventional insulation. The highly reflecting chromium plated oven walls materially contributed to cutting down heat losses. Then work began on heat leakage through multiple air jackets and very shortly it was evident that the combination of a double air space and chromium plated oven interior was substantially the the equivalent of the insulation commonly employed, with the important difference, however, that the oven space got hot in about one-sixth of the usual time with a correspondingly smaller heat loss.

Progress in the development work was now far enough along to begin to think constructively about design. It must be stated that both the development and production engineers were all automobile industry men, accustomed to quantity production and thoroughly acquainted with the difference between something that was to be built and something that was to be manufactured. This very important difference is often overlooked with the result that not infrequently construction suitable only for building methods are carried over to a manufacturing plan with more or less unfortunate results. We had already begun to project in our own minds the enormous potential demand for an electric range that could be sold in direct competition with ranges using fuels of various natures. We all appreciated that a policy of a single model would permit features tending to low cost. A product that could be assembled in various ways to suit conditions without change of the individual units was needed. In other words, it was desirable to build an oven that was in itself an oven, and a cooking table that was a cooking table without reference to the oven. Our range committee told us that stoves had to be made with ovens on the right and ovens on the left, and there we bumped into the matter of the legs.

Obviously, if we had a right-hand oven the leg came right under the right-hand corner of the oven; if we had a left-hand oven the leg inflicted itself on the opposite corner. It was already decided as desirable to draw the oven shells direct from sheet steel and the obvious merits of the rounded corner both for enameling reasons in the shop and for ease of cleaning in the home had been expatiated upon at great length. Finally the question was asked: Why does one absolutely have to have a set of four separate legs to make a stove? Would it not be just as satisfactory if we had a stand that supported the units in such a way as to hold them rigidly and conveniently at the right height? Beyond that, why, in an apartment house for instance, could not a stove be hung on the wall and thus dispense with the legs or stand entirely? In the end, the idea solved a number of problems. It permitted duplicate units, it enabled the assembly of right- and left-hand stoves without change of parts, and it opened up a path to colored ranges that has not as yet been traveled but upon which we shall soon have to excursion.

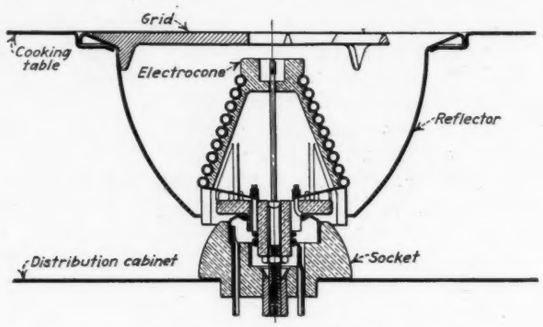
All of us were greatly afraid that the feminine element would cry loudly for the time-honored legs. We men folk sat around by the hour and worried about our legless baby. It was perfectly all right and there wasn't any reason why it should not be that way, and it was undoubtedly a good production proposition and while it might cost a little more in one direction, it cost a little less in another—but—and then everybody would quiet down and say "but" again and admit "it is radical." After some of the models were built and were shown to the women-folk, a most extraordinary thing was discovered. Less than one woman out of fifty made any remark whatsoever about the fact that this product had no legs. Odd though this be, it has been carefully rechecked since stoves began to be distributed to the public and seems to be so.

Originally, the intention was to make a stove without any automatic features, but as time went on, a complete series of automatics were developed that intrigued their makers to the point where they nearly fell into the pit dug



THE OVEN
The "rack" just below the upper shelf contains the coils. The walls are chromium plated

by so many electric range manufacturers; meaning that we nearly lost sight of our original intention to make the simplest, cheapest, most competent piece of apparatus that could be properly constructed. There is a legitimate popular demand for good temperature regulation even on



THE HEATING UNIT
Details of Construction

a "base" range, and despite all exhortation to the contrary, a thermostat that was reasonably accurate, reasonably inexpensive to build, and which controlled the oven very nicely, was made.

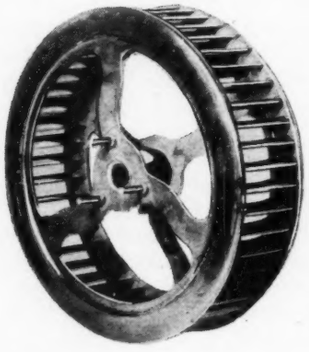
Having assembled a general design as an aftermath of the year's work, the development proceeded to the model building stage. The original models were made with the thinnest gages of metal in which anyone could imagine such forms fabricated. The ramshackle parts were fattened up. Some of the others were cut down. Everyone was certain that, if the models were "over built" to start with, no one would entertain a proposition to reduce their weight, with the result that some day very large sums of money might be spent for totally unnecessary mass. The outcome has been eminently satisfactory.

With the completion of what seemed to be a fairly satisfactory model, the practical every-day work tests began. Cooking schools took ranges and used them intensively for the equivalent of some years of ordinary home service. As many diverse opinions as possible were secured in order to get a fair cross-section of the public reaction. Every criticism, whether reasonable or unreasonable, was taken seriously and many of them proved to have the utmost value in clearing up minor objections. In the end, everyone connected with the project felt that we had a "cooking machine" (we coined the name) that was a better cooking machine than had hitherto been produced. With that belief and with a confidence that the machine could be produced at a reasonable cost, we were faced with the problem of what to do with it.

The belief was general with us that something had been made which possibly could be manufactured. But we also believed that the estimated cost of something that can be manufactured and the actual manufacturing cost are two different stories, anywhere from one to ten million dollars apart. It was decided to set up a pilot plant as distinct from the experimental room; a plant that could be devoted to an accurate time study of the processes involved, to the analysis of the operations and the perfection of tools, and in which all the parts could be manufactured or treated in sufficient detail to ascertain their costs thoroughly. This pilot plant is now in operation, and from it comes a "by-product" of stoves called "Electrochef."

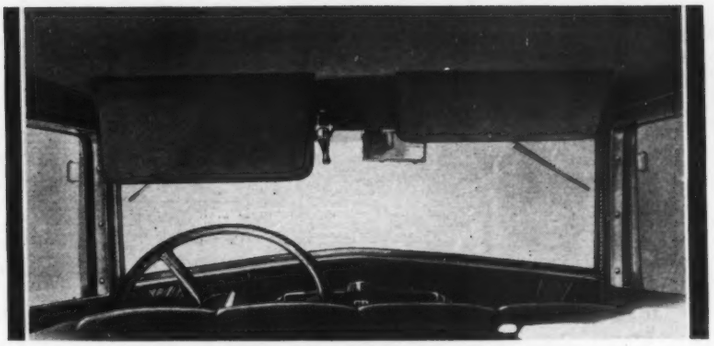
REDESIGN FOR PRESSED CONSTRUCTION

By VERNON B. CHASE
Vice-president,
The Metal Specialty Company



PRESSED metal parts were substituted for the two forgings and the casting shown at the left with rather imposing results. The bracket clamp forging at the upper left became the pressed-metal unit at the right, losing 30 per cent in cost and 37 per cent in weight, and gaining considerable strength. A 60 per cent reduction in cost and a 50 per cent reduction in weight, as well as the elimination of all machining and a decided improvement in appearance, resulted from redesigning the forged yoke. The cast-iron turbine wheel was reduced in cost 35 per cent, in weight 25 per cent; strength was increased, performance improved, and machining eliminated in the changeover.

1930 design trends in MOTOR CARS

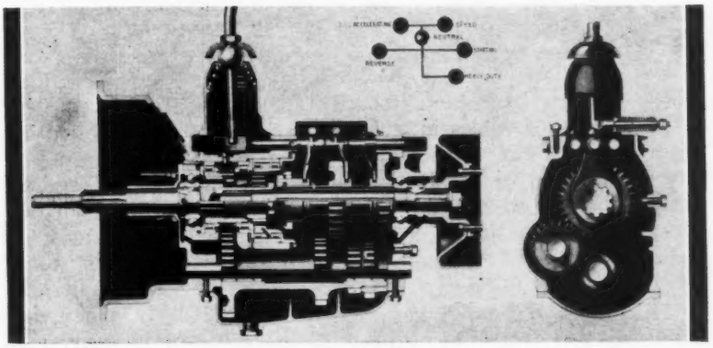


INTERIOR, adjustable, anti-glare visors as fitted on Hupmobile closed bodies

By HERBERT CHASE

WHETHER the net results of the trend toward more cylinders are justified, either on purely engineering or on economic grounds, is at present a matter upon which opinions differ. Many cars, including some with six or less cylinders, are equipped with engines developing, according to published data, one horsepower for each 30 to 40 lb. of car weight unloaded —a considerably higher power-to-weight ratio than has been customary in the past.

Considered as a whole, sixes have undergone relatively little change in design, aside from detail refinement. Most of the new eights also follow rather conventional in-line practice. An exception to this rule is the new Oakland V-type eight, which, instead of using a crankshaft with crankpins in planes at right angles to each other, has a single-plane shaft. This results in a less expensive crankshaft, simpler manifolding and a somewhat better firing order.



FOUR SPEED Chrysler gearset used to give lower average engine speed with rapid acceleration in "third"

A "synchronizer," as it is termed, is employed to counteract the unbalanced rocking couple which this arrangement involves. It comprises a lever pivoting about a pin fixed to the front end of the engine, and a spring-loaded plunger bearing against the lever a short distance above the pivot. A roller on the upper end of the lever is held in contact with a four-lobe cam on the front end of the camshaft. As the camshaft revolves each lobe of the cam forces the lever and the plunger outward, producing a timed reaction tending to counteract the rocking moment. The outer end of the plunger is clamped between plates of friction material fastened to the chassis frame.

In the Oakland engine, as in many others, including chiefly those with vertical cylinders, down-draft carbureters or manifolds or both are fitted. This arrangement increases the maximum power output partly because, according to some statements, a larger size of carbureter can be used and still maintain adequate mixture velocities. Down-draft carbureters are placed above the manifold, and are fed by cam-actuated pumps using diaphragms, in preference to pistons to avoid leakage and lubrication difficulties.

Engine lubricating systems have undergone little change, but the new Hudson eight employs in its splash lubricating system a neat double-acting pump, the plunger of which is given a combined reciprocating and rocking action by a ball eccentrically mounted on the end of the driving shaft and fitted into a socket in the plunger. Pumping results from the reciprocating motion, and rocking of the plunger successively opens and covers ports taking the place of valves.

The latest Hupmobile eight employs an oil cooler built as a section of the main radiator core. Circulation through the cooler is accomplished by the same oil pump that feeds the engine bearings. A relief valve, separate from that in the pressure feed system, prevents the application of excessive pressure to the radiator when the oil already is amply cool and viscous.

Crankcase ventilating systems are almost universal. Many of them have outlet pipes discharging underneath the car. Air circulation through the crankcase is brought about partly by using air-bell intakes back of the cooling fan. This circulation tends to remove water vapor and other combustion products as well as fuel vapors from the crankcase, thereby reducing or avoiding the oil-dilution and corrosive action heretofore the cause of serious difficulties. Some crankcase ventilating systems have air filters, but the use of such filters at carbureter inlets seems to be decreasing. Many of those used employ oily copper "wool" or other filtering material instead of a centrifugal cleaning device.

Pistons of aluminum and magnesium alloys, many of them fitted with Invar or other struts designed to maintain approximately constant clearance regardless of variation in temperature and thus to void piston slap, are found on more models than formerly. Greater wear resistance has been gained in some of these alloys by

increasing the silicon content to a point where tungsten-carbide tools are required for machining. Some prominent companies continue to use cast-iron pistons because of their wear resistance and the lower coefficient of expansion of cast-iron as compact to light alloys containing aluminum.

It is now common practice to use rubber mountings to insulate the engine from the frame, and thereby to reduce the transmission of noise and vibration to the body. Three-point engine mountings are less common, partly because of the yielding connections used and partly because frames have been stiffened to such an extent that excessive stresses upon the crankcase arms attached to the frame are unlikely to occur.

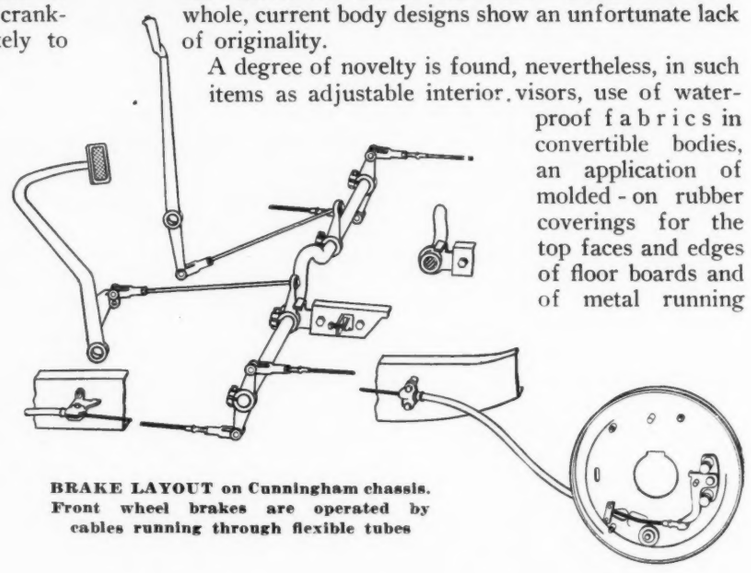
Gearsets with four speeds have gained several converts, the net advantage being reduced engine wear, better fuel economy, and quieter operation. Quietness in next-to-top speed virtually equal to that in high is gained by the use of a spur gear engaging an internal gear, of constant-mesh herringbone spur gears engaged by jaw clutches, or of spur gears of conventional form having teeth finished with extreme precision. Reo is employing herringbone gears, the two halves of which have teeth of different pitch intended to prevent or at least to minimize chatter.

Brake actuation and adjustment systems have been simplified on many cars, partly by the use of cables in place of rods. In many designs a foot or more of the cable passes through a flexible tube, one end of which is attached to the frame and the other to the brake anchorage plate. This gives a neat appearance and results in reducing the total number of parts by as much as 50 in some cases.

Refinements in steering systems include the use of hour-glass worm gearing and of more anti-friction bearings for the gear at the lower end of the steering column. The transmittal of shock to the steering wheel has been minimized in some cases by using rubber shackle fastings or providing a shackle at each end of the left front spring and positioning one of these shackles with supplementary cushioning springs. The use of sectional metal casings for covering springs and retaining lubricant is becoming more general. Double-acting hydraulic shock absorbers are much more widely used than formerly.

Efforts to reduce over-all height in bodies without undue sacrifice in headroom continue. Bodies also are being built somewhat wider. High and narrow radiators and hoods are almost universal. Considered as a whole, current body designs show an unfortunate lack of originality.

A degree of novelty is found, nevertheless, in such items as adjustable interior visors, use of waterproof fabrics in convertible bodies, an application of molded-on rubber coverings for the top faces and edges of floor boards and of metal running boards, an increased use of polished stainless steel and chromium plating for exterior fittings, instrument boards made with a wood face veneered on metal, wider application of shatter-proof glass, and more general provision of quick-adjusting seats and windshields.

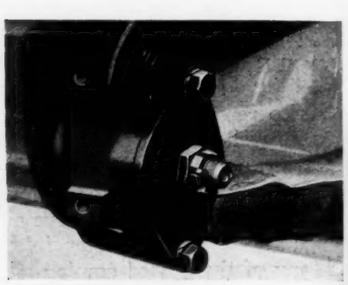


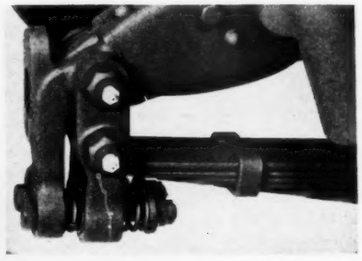
BRAKE LAYOUT on Cunningham chassis. Front wheel brakes are operated by cables running through flexible tubes

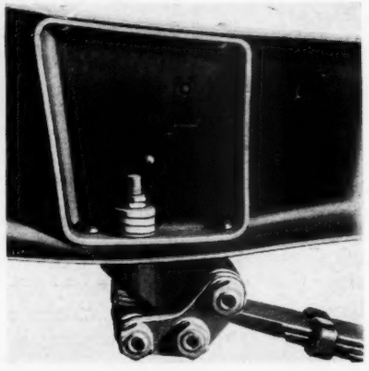
Bowed or peaked visors, most of them quite narrow from front to back, are coming to be more common. The visor of today is designed as an integral part of the body, not added as an afterthought as it was in many cases a few years ago. Roof lines also have been changed in some cases, an innovation being the roof that is peaked as viewed in front elevation. Considerable variations in appearance also have been brought about by changes in the arrangement of hood louvres or by providing in their place a series of small doors.

Body structures have been improved by wider use of pressed steel reinforcements of wood frames, and of wire mesh for roof deck support. The practice of stamping moldings integral instead of applying them separately is gaining ground. All-steel bodies are used on some large-production models, but composite wood-frame steel-covered bodies still are most widely employed. Some cars are fitted with fenders and splash aprons of rust-proofed steel.

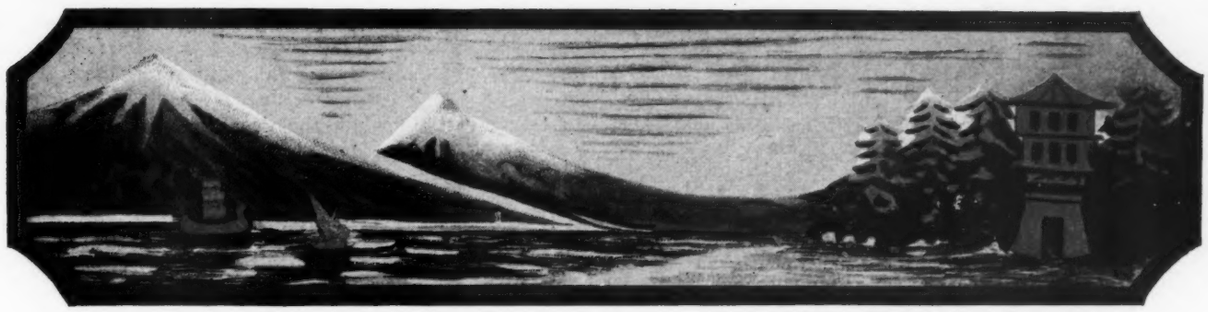
Viewed as a whole, the current models show advances both mechanically and artistically at least equal to if not greater than those of most recent years.







FRONT SPRING mountings designed to prevent wheel wabble. Upper right, Buick shock eliminator: Lower right, Hupmobile shock eliminator at rear end of spring: Above, Graham rubber-bushed shackle



Household products are widely ornamented

DECALCOMANIA

for PRODUCT MARKING and ORNAMENTATION

Illustrations from Meyercord Company, and National Decalcomania Company

APPLICATION of the trademark, company name, or other markings on the product is one of the small points too often left out of the designer's calculations, although from the sales standpoint it is highly important, especially in a competitive field of quantity products where small details of finish may affect the sales. Provision should be made in the design of the product itself for any required label so that it will add to, rather than detract from, the appearance of the machine or product.

There are various methods used for applying the trademark, such as by means of metal nameplates, casting or stamping in the name, painting, stenciling, or by the transfer or decalcomania process. This article will be confined to a description of the latter process in its application to metal products both for marking and for the simple purpose of ornamentation.

Decalcomania is a comparatively new art, having been introduced into the United States from Germany about 1880, and at first employed only for decorative or novelty work. As a commercial process for labeling and decorating mechanical products, it has only come into wide use within the last few years, coincident with the increasing attention to the sales appearance of the product. The process of application is simple, and is capable of giving results with ordinary operators that would be possible otherwise only with highly skilled artists. Other advantages of this transfer process are its economy, speed of application, and durability in service.

LABELS like this are useful in identifying the rebuilder of a product

The decalcomania itself may be considered as an oil color design superimposed on paper coated with a starch adhesive, known as dextrine, so that by softening this coating in water the design may be slid off onto the surface to be finished by it. The color design itself is waterproof, and is not injured by the dissolving of the starch coating. Most commercial transfers for ordinary products, except designs having open lettering, are of the slide-off type, and the design sticks to the metal surface by means of the gum on the paper. For large work, however, this type is not easy to handle and position accurately, and the older type of varnish reverse decalcomania is used. In this type the design is printed in reverse on the paper and a varnish or glue is used to effect the transfer. Designs having open lettering without a solid background must necessarily be placed on the reverse type of decalcomania and applied with varnish, since it is not possible to slide off a design unless it is completely closed up and continuous.

Varnish transfers are usually "duplex" or printed on double paper. The design is on a soft tissue paper, which is backed up by a heavier backing paper. In applying the design to the product, it is optional whether the product or the decalcomania transfer be coated with a quick-drying spar varnish. When the varnish has dried sufficiently to become tacky, the transfer is applied to the product, and the heavy backing paper is stripped off while dry. The transfer tissue is then squeegeed in place

DECORATION is now employed on a wide variety of products **AUTOMOBILE** monograms in decalcomania will withstand weathering

and sponged to loosen it. When the tissue is soaked with the water, it is easily stripped off, leaving the design in place on the article. The surplus varnish film is removed with a rag dampened with benzine or other solvent.

If the designer desires to adhere to the slide-off method of decalcomania, he must see to it that his trademark or ornamental design is closed, that is, there are no detached letters or figures. For this purpose, it is not necessary to join the letters, since the whole can be joined into a continuous unit by having a background of color in the design.

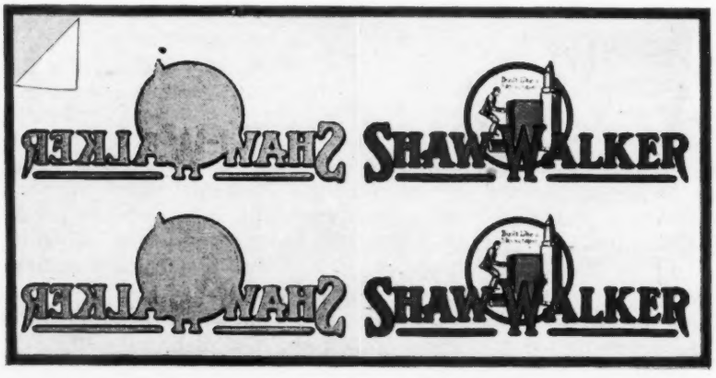
For labels for outdoor use such as on gasoline pump standards, it is necessary to apply clear nitro-cellulose lacquer on both sides of the transfer in order to preserve it against weathering. Duplex paper is first coated with lacquer, the design is printed face down, as with other duplex transfers, and an opaque white cover coat is printed on top, followed by another cover coat of clear lacquer. Such labels are always solid and of fairly regular outline. They must be die cut from the sheet. This necessitates the added expense of another operation, aside from the die cost, which must be absorbed.

The process of printing decalcomanias is a branch of lithography. Since the preparatory work of making the designs on the stones requires highly skilled workmen and is expensive, it is obviously desirable to contract for the largest possible quantities in order to obtain a low unit cost. In the marking of such products as radios and household machines where the production is large, elaborate designs can be called for with extremely low cost, say one or two cents, but on large machines where few are required the cost may be excessive. On slide-off decalcomanias, the colors are printed on top of a base made up of one or more printings of special white ink. This base coat is necessary so that the design can be handled after it is slid off the paper. Its opaqueness is also useful in preserving the original shade of the semi-translucent colors, particularly when the decalcomania is placed on a dark colored object.

A separate stone is used for each color printing. These printing stones, which are run through flat-bed presses, are made by a transfer and etching process from smaller stones on which the original design is painted by hand. It is also possible to transfer the designs to etched zinc sheets for use in rotary presses. The artist works from a sketch furnished by the product manufacturer or from a finished drawing that has been approved by the manufacturer or product designer.

DECALCOMANIA makers are usually prepared to do this art work for the manufacturer. The stones are ground and polished accurately, and the separate color forms must be registered precisely with each other, as in all color printing. It is this hand preparation and registration of the stones that makes the first cost high. Special grades of imported paper are employed, and special lithographic inks are necessary.

Between each color printing, which may number as many as 15, the sheets are racked individually to dry, and the humidity and temperature of the printing plant is kept absolutely uniform by automatic regulators so that the registration of the color forms will not be changed by differences in expansion or contraction of the paper. A large number of runs are required because certain colors are printed twice to bring out the full depth of shade. In fact, one of the difficulties is to make the ink adhere and to build up the proper shade; for this reason, multiple printing is an assurance of quality. It can be seen, therefore, that the printing process is more elaborate and costly than color printing.



WHERE OPEN LETTERING is employed, the transfer is printed face down on duplex paper. After the transfer is mounted in place on the object, the heavy backing paper is stripped off, and the light tissue removed by sponging

Decalcomania marking and decoration is used for a wide range of products such as: typewriters, sewing machines, radios, switch boxes, bicycles, metal furniture, toys, metal containers, refrigerators, street cars, and any kind of machine or instrument where a plain surface is available. It is applied to curved surfaces such as handles, where any other kind of marking would be very expensive. An advantage for

DECORATIVE effects may be had in a variety of designs and colors. Patterns placed on metal furniture are an example of their use

machine marking is that artistic designs in many colors can be applied that could otherwise only be produced by hand at great cost. This point is important on machines designed for household use. Decalcomanias are also widely used and have a special field in the truck equipment line. Hand lettering and the most elaborate trademark designs created by master artists at great expense can be accurately reproduced and standardized in decalcomanias at a very low figure, and in addition to the economical advantages involved, there is the important element of time saved in getting the equipment on the street.

Many decorative effects can also be obtained by decalcomanias. The fine designs seen on metal furniture are put on in this way. All fancy borders on Pullman car interiors are also transfers. It is even possible to produce imitation wood effects on steel with the use of decalcomanias, and attempts are now being made to substitute transfers for veneer on furniture made of cheap wood.

While decalcomanias for commercial use have plenty of body or thickness to insure easy transfering, they are comparatively so thin and their adhesion so perfect that once transferred to a product they actually become a part of the surface itself. Since they cannot be removed without injuring the surface of the article when once applied, they furnish a very definite means of insuring the continual exposure of the trademark on the product as permanent as the original finish over which it has been applied.

THIS SEAL of approval is a decalcomania transfer

Most of the work of applying the transfers to the product is done by girl operators, with the work laid out progressively on benches. Certain manufacturers, however, have developed machines for applying the transfers automatically, although to date these are all special and are only suited to the particular manufacturer's requirements.

ON SLIDE-OFF decalcomanias open lettering cannot be used except by closing with a background. A field of white, black, or any color may be used for this purpose

WHILE the product designer may not be an artist in the ordinary sense of the term, he must necessarily exercise a certain supervision over any ornamentation that is added to his product either for marking or for making it more attractive. The test of artistic application is that it should not appear to be added as an afterthought. The designer of any ordinary commercial product must see that the design of ornamentation added is "conventional," that it is given the treatment which expresses the use and purpose of the article.

Conventionality in ornament implies restraint and the use of only that art called for by the occasion, and not all that the artist might have done. It must be remembered that the effect of art is an effect upon the feelings of the user of the product, and in a commercial product there must be a strong consideration of its place and purpose. A product that is to be sold for household use will naturally be adapted to considerably more ornamentation than one that will be installed in a shop where the effect on the user is quite different.

There is no greater fault in ornament than the mistake of going too far. The artist who is not imbued with the spirit of the product, as the designer is apt to be, is easily inclined to do more than the conditions justify. In product it is the extent of liking that the user has which must be fathomed. In determining the limits of decoration, therefore, the personality of the artist must be guided by the mechanical background of the designer, and by the latter's knowledge of the field in which the product is being sold, avoiding, of course, the designer's own inclination to be over conservative and to follow beaten tracks. It is along this line that the designer who intends to make use of such ornamentation as the decalcomania can avoid leaning too far in either direction by cooperating with the manufacturer, whose specialized experience is in a wide field, and who usually has a staff of experienced artists familiar with ordinary commercial products, as well as with the possibilities and limitations of decalcomania.

Frigidaire
Automatic Refrigeration
FRIGIDAIRE CORPORATION, DAYTON, OHIO.
MADE IN U.S.A.

A SIMPLE slide-off decalcomania transfer used for the trademark of a metal product. It comes mounted on paper from which it can be slid off after immersion in water

AN ornamental design

COMMENT AND SUGGESTION

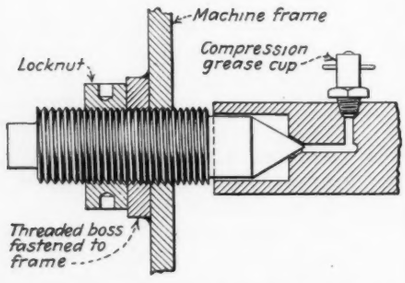
Pivot Bearings

By P. H. White

DISTINCTIVE advantages of the conical pivot bearing, namely low frictional losses, ease of adjustment, and cheapness, are known to most engineers. This type of bearing is widely used, particularly in watches and some types of textile machinery. That they are not adapted to heavy loads, on account of the resulting high unit bearing pressures, is well known to every machinist from his experience with lathe centers. However, pivot type bearings may be successfully used for shafts or axles driven by the smaller fractional horsepower motors, yet designing engineers do not appear to take much advantage of this fact.

The conical pivot bearing shown in the accompanying illustration is used on a small ventilating fan, 14 in. in diam. and 14 in. long, driven by a $\frac{1}{4}$ hp. motor. The pivot is made by threading a short pieces of steel and turning one end to a 60 deg. point. The opposite end is flattened for a short distance to form a hold for a wrench. The pivot may be either of tool steel, hardened and tempered, or of cold rolled steel, case hardened. The point must be hard enough to withstand abrasion, the unit bearing pressure being relatively higher.

The end of the fan shaft is finished by counterboring to a depth somewhat greater than the total



Conical pivot bearing used on each end of shaft of ¼ hp. belt-driven 14x14-in. ventilating fan.

length of the taper on the pivot. This will prevent the shaft from falling out entirely should the end of the pivot get out of the bearing. The end of the shaft is case hardened to resist water. Lubrication is furnished through a $\frac{1}{8}$-in. compression grease cup.

The pivots are screwed into threaded bosses on the frame of the machine, and are held in proper adjustment by means of a lock nut.

This ventilating fan has been in operation for two years, the bearings having proven satisfactory in every respect. Pivot bearings, properly designed and made, are undoubtedly applicable to numerous other similar installations. Their obvious advantages warrant their serious consideration by the designing engineer for installations involving the motors of fractional horsepower and where it may be reasonably expected that the bearings will be kept properly lubricated.

■

STOP... LOOK... LISTEN...

•

. . . ROUGH-NECK MACHINERY . . .

EVER SINCE "The Trail of Ninety-Eight" started a string of mining and construction stories there has been a popular opinion that construction men are "rough-necks." Apparently designers of construction machinery don't think so, for recent models in such things as road-rollers and graders show stream lines and bright paint colors that rival those of high-priced automobiles. One new design of crawler tractor places the gasoline tank crosswise on the frame and flares the engine hood from the radiator in order to get a pleasing streamline effect.

•

. . . STATISTICAL CO-EFFICIENCY . . .

BELIEVE it or not (we have the documentary evidence received prior to the New York Automobile Show from reputable publicity sources) one prominent 1930 model motor car is provided with "a high co-efficiency molded brake lining." Another, we are told, has not only perfectly balanced "reciprocal" parts, but is fitted with a crankshaft that is both "statistically and dynamically balanced!"

Quite in line with the Volstead law, we observed, most cars were fitted with dry-plate clutches, but, on the other hand, nearly all engines were provided with dampers, while the prevailing rear axle was either semi- or three-quarter floating.

•

. . . WELDS AND HIGH STRESSES . . .

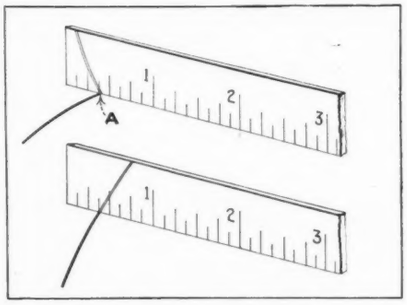
PAUL BURKE, chief engineer of the Northwest Engineering Company, a company that has brought out some real things in the way of power shovels and cranes, is quoted as saying that the reason welding

■

Drawing a Tangent to a Curve

By Walter J. Charles

A STEEL scale polished on one side may be used to construct a perpendicular to a curve at any point. The method can readily be understood by reference to the accompany-



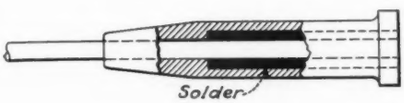
ing figure. The reflection of the curve in the scale may form a sharp cusp as shown in the upper portion. If this is the case, rotate the scale until the cusp disappears and the curve is smooth and continuous, as shown in the lower portion of the illustration. The scale will then be perpendicular to the curve. Repeating this process at two points will determine the center of the curve. A line perpendicular to the scale where it crosses the curve will be the tangent to the curve.

This method is especially suitable for locating the successive centers of curves that are not true circles; that is, to enable one to construct with a compass close approximations to a curve by drawing a series of arcs whose centers are located as above.

End Connection for Small Wires

By George A. Fries

WHERE small wire, such as piano wire, is used for transmitting a pull in a mechanism, it is the usual custom to bend or loop the wire at the end to fasten it. For ordinary conditions where there is a steady pull on the wire, this method of construction is perfectly satisfactory. But where the wire is subjected to repeated stresses, the result will be the failure of the wire at the point where it is looped. The accompanying figure shows one method of fastening small wire, which does not require bending of the wire. In the construction shown, the wire is subjected only to tension. The bending stresses existing in the loop ends of the ordinary correction have been eliminated. It is these bending



stresses which cause ultimate "fatigue" failure under repeated loads.

The length of the solder seat should be approximately ten times the diameter of the wire. The thimble may be designed to suit conditions. The end may be flanged as shown or the thimble may be threaded either male or female. In appearance the construction is similar to that used with standard steel cable. In the latter case, however, the strength of the joint is obtained by splaying out the strands of the cable. In the design shown here, for a single-strand wire, the strength of the joint is determined entirely by the strength with which the solder adheres to the wire.

■

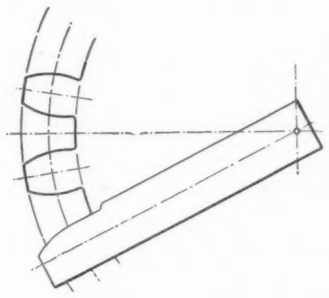
Templet for Gear Drawing

By Kenneth Stover
Draftsman, Fred Medart Mfg. Company

IN THE engineering departments where many drawings are made on gears and sprockets, it sometimes becomes a slow and tedious process to draw in each tooth individually with a compass. Much time and patience may be saved by making a set of simple templates as here shown of hard stiff cardboard or thin boxwood. In the center and near the end a hole is made so that a pin can be used as a fulcrum.

After laying out the pitch, addendum and dedendum circles, and the centerlines of the teeth it is a simple matter to place the template on the paper, line up the template centerline with the teeth centerlines and draw in the half contours of the teeth by turning the pivoted template. By turning over the template the other side can be drawn.

As it is just as easy to draw in with a ruling pen as in pencil, time can be



saved in laying out any kind of gears or sprockets having a large number of teeth by this method and, if care is taken in cutting out the template, very accurate results can be obtained.

■

High Speeds for Tractors

By G. B. Stuart

AN INQUIRY received by an American tractor company from South America for a tractor that would haul 20 tons over rough dirt roads at 20 miles per hour led to some live speculation among the engineers. None of the commercial tractors would do the job, but the specifications are well within the range of possibility, much depending, of course, on the driver and his familiarity with the road.

Tractors are seldom called upon for speeds above 4 miles per hour, and the "caterpillar," or endless track, is the part that is the least durable under the high speeds. However, endless tracks, with stamped steel plates, have been built for tanks that give a life of 3,000 miles at speeds of 12 to 18 miles per hour. These plates are bushed for the pivot pins. The "dragons" of the British mechanized force weigh about 9 tons and are capable of 16 miles per hour towing a 3.3-in. gun, 11 men, and ammunition. A new British 16-ton tank has a 180-hp. air-cooled Armstrong-Siddeley engine and has a sustained speed of 16 miles per hour, or 32 miles per hour at high speed. The new American Christie tank, with steel track, is claimed to have a speed of over 40 miles per hour.

Possibly the solution for high-

has not replaced riveting on booms, dipper sticks, and frames in the heavy types of construction machinery is the lack of confidence in the distribution of stresses in the long welds. Here is an admirable field for welding if somebody starts something. The chief engineers are receptive to being shown, but the propaganda must also be outside!

•

. . . APPEARANCE FIRST . . .

THE *Mechanical World and Engineering Record* states that British motor car builders are very much dissatisfied with chromium plating although recognizing its corrosion-resistant advantages in place of nickel plating. The peculiar color of chromium is what effects the aesthetic eye of the English car buyer, and apparently they are not alone in this. At the Motor Boat Show in New York in January the representative of one manufacturer of a newer type of "stainless" steel brought out the point that the builders of fancy boats are inclined to jump the fence on straight chromium plating and go to the high-chromium steels although parts made of them may cost twice as much as the old nickel-plated parts. The color is as good as chromium, and the life is long.

•

. . . CHOCK FULL O'RESIN . . .

EVER seen a motor armature in which the only visible parts were the shaft, the commutator segments, and the periphery of the laminated core, the remainder being encased in molded insulation? Recently we were shown such an armature for a fractional horsepower motor and were told that complete motors with all parts molded into a phenolic-resin mass are to be produced in quantities in the near future. Such motors are said to weigh about half as much as motors of equal power made in the conventional way, and to be capable of rapid production at low cost.

Just what may come of this development we are not prepared to say, but it seemed to embody possibilities in the way of compact molded assemblies that well may be studied with much profit. Some capable judges predict a very bright and increasingly important future for molded products in many fields of engineering.

•

. . . NO MORE HARD LABOR . . .

DEVICES to make life easier and work more pleasant for the operators of construction machinery were much in evidence at the road machinery show at Atlantic City in January. These included a spring seat mounted upon a hydraulic pedestal for the rough-riding tractors, and hydraulically-operated clutches on power shovels. Not only has ditch-digging been mechanized, but a gasoline-driven tamping machine was shown for smoothing the backfill. When the next war comes there won't be any more hard labor jobs for the soldiers!

speed commercial work will be the rubber-jointed or the rubber and fabric track. The Russian "Kegresse" track has driving lugs spaced along each side of an endless fabric band, and rubber-padded metal shoes. The advantages claimed are: no lubrication, no damage to roads, less noise at high speeds, easy to replace worn shoes, and speed over rough country. The disadvantage may be less tractive power.

■

The Little Things that Count

By F. M. Williamson

I WAS interested in an article under the heading "The Seat of the Trouble" in the January number of *Product Engineering*. It brings this to my mind, how we admire a beautiful flower without giving thought to the man who cultivates the plant so as to produce the result. This is true of the engineering profession, the "little man" who does the actual work and the detailed thinking is not thought of by the public when it views an intricate piece of machinery. The engineer in charge, like the gardener, is given credit, and this is proper because these things could not be accomplished without proper generalship, but the "little man" deserves credit for his part. He is so busy out in the front line trenches that he is seldom seen by those behind the lines. Therefore, it seems to me that there is a vast field in this line of work for a magazine pertaining to details.

■

Unit Design in Castings

THE NEW "Commonwealth," one-piece, cast-steel locomotive bed, shown at the bottom, is not only an example of the remarkable work being done in this line, but also illustrates how the designer may incorporate various parts into a single unit. In this locomotive bed casting there are embodied not only the two main frames of the locomotive, but also the cylinders, cradle, deck castings, cross-ties, brake hanger lugs, equalizer fulcrum and all the various fillers and brackets formerly forged or cast separately and bolted together to form the frame assembly. Many similar designs also include the pilot beam and air-pump brackets, the latter being cast forward of the cylinder saddle.

The advantages of such unit construction are the elimination of hundreds of machined bolts, nuts and miscellaneous parts, a more rigid and durable foundation, simplified construction and the resulting saving in maintenance costs. The same principles may be applied to designs of castings for other purposes than locomotives.

The bed shown in the picture is designed for a Delaware, Lackawanna and Western fast freight locomotive of the 4-8-4 type. The casting weighs 58,100 lb. and is 56 ft. $\frac{3}{4}$ in. long, overall. The finished cylinders are 28 in. inside diameter.

■

Simple Gear Ratio Formula

By Jack Best

Newman Machine Company

WITH a given center to center distance, the total number of teeth in a pair of spur gears connecting two shafts will be equal to twice the center distance times the diametral pitch. If T be the total number of teeth, R the desired speed ratio between the two shafts, and z the number of teeth in the pinion, then

$$z = \frac{T}{R \times 1}$$

This equation is very convenient to use when determining the numbers of teeth in pairs of gears having fixed center distances, as in selective feed gear boxes and spur gear speed reduction units.

For example, two shafts are 5 in. apart and are to be connected by a pair of gears having 6 diametral pitch. There will be a total of 2x5x6 or 60 teeth in the pair of gears. Assuming a speed ratio of 3 to 1 were desired, then

$$z = \frac{60}{3 + 1} = 15 \text{ teeth in the pinion}$$

The gear would of course have 60 — 15 = 45 teeth.

This method of calculation is of greatest value when the speed ratio and the center distance are not represented by simple prime numbers as in the example given below. In any case the tedious trial and error calculations often resorted to are eliminated.

■

Checking Drawings

By Burton Matthews

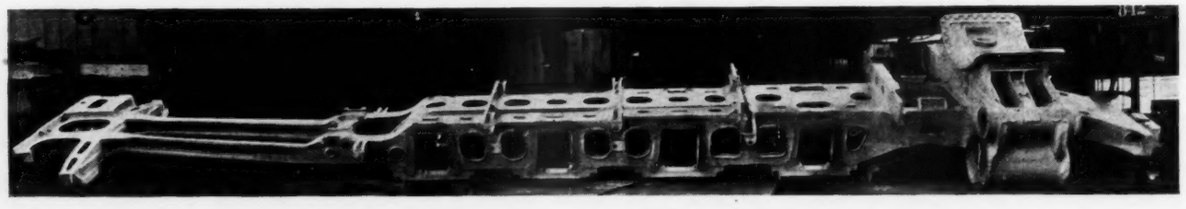
National Automatic Tool Company

AFTER experience with a dozen or more systems of checking drawings in the drafting room I have come to the conclusion that the following system used by one of our most progressive machine tool manufacturers is quite superior to the average.

The first salient feature of the system is that, although the checker makes a thorough check of the drawings he puts no figures upon the check print. He only circles with a yellow pencil all dimensions and other information which he believes wrong. Under each item so penciled he puts a key letter. On a separate sheet of paper he lists opposite the key letters the correct dimensions, and notes the other mistakes. This sheet is retained by the checker.

As a result, when the check print is received by the detailer he is compelled to recheck his work and correct it, whereas, had the correct figures been placed upon the blueprint, he would probably have copied them without bothering his head to find out whether they were right or wrong. After all the corrections have been made the checker fastens his key slip to the check print and places it in his private file.

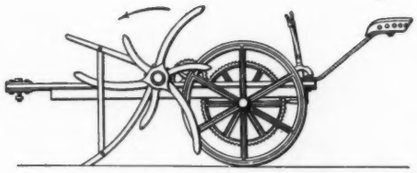
The second noteworthy feature of this system is the routing of the work. This is simply: designer to detailer, detailer to squad boss, squad boss to checker. Then, on the return it is: checker to squad boss, and not checker to detailer, as is usually the case. This routing eliminates direct contact between the checker and the detailer. The squad boss is the mediator between the two.



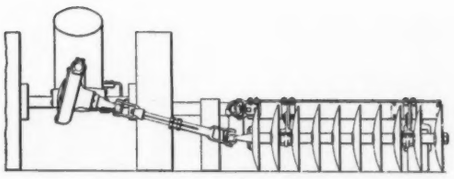
AGRICULTURAL MACHINERY

RECENTLY PATENTED

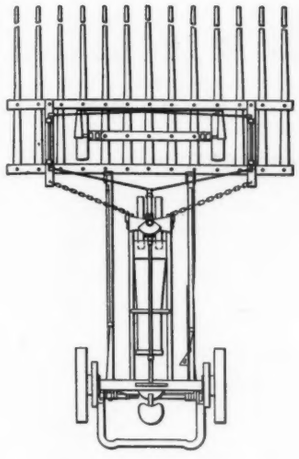
United States patent number precedes each caption



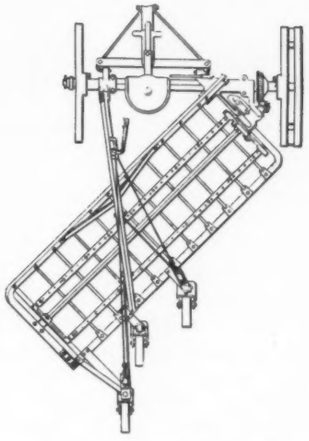
1,731,607—Vine trimmer



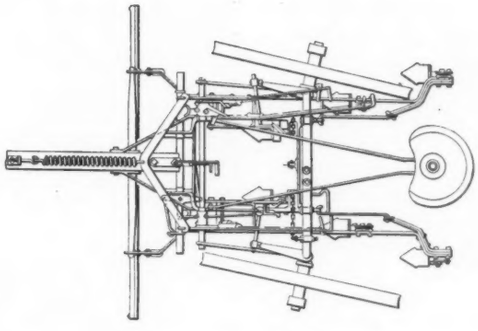
1,729,073—Harrow power drive



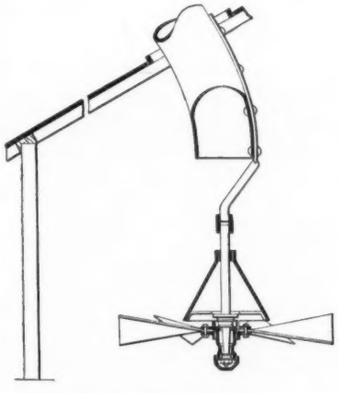
1,729,084—Tractor sweep rake



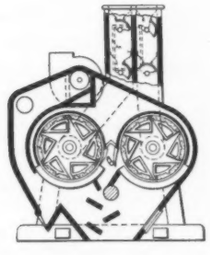
1,728,301—Side-delivery rake



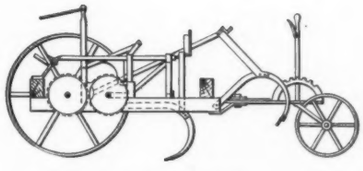
1,731,509—Cultivator



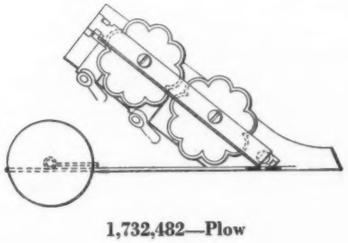
1,729,341—Ensilage distributor



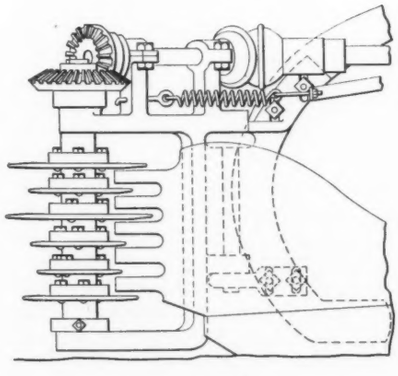
1,731,871—Grain husker



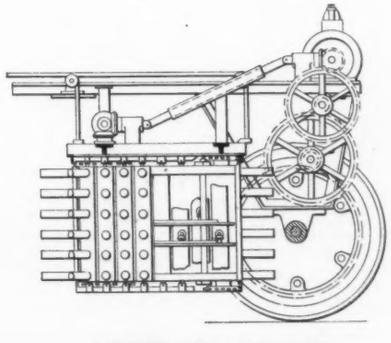
1,731,579—Self-dumping weeder



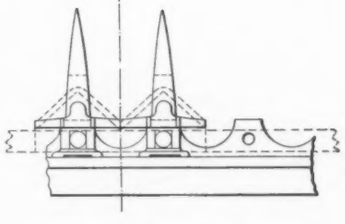
1,732,482—Plow



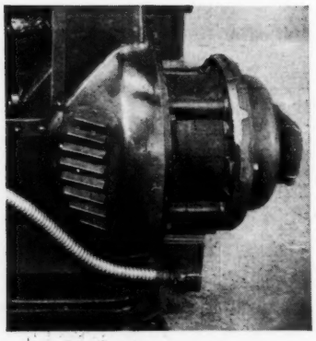
1,732,862—Plow



1,728,556—Cotton harvester

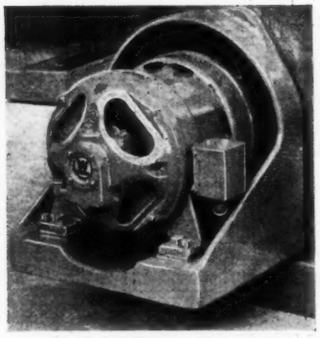


1,731,434—Harvester finger bar



FLANGE - MOUNTED motor arrangement on Gould & Eberhardt shaper

FLANGE- or FOOT-MOUNTED MOTORS?



FOOT - MOUNTED motor arrangement on Gould & Eberhardt shaper

INCREASING interest is being displayed by designers of power-driven machines in the possibilities of mounting motor by flanges rather than on feet or pedestals. This fact is made apparent by numerous comments resulting from the article "Flanged Motor Mountings on Foreign Machine Tools" in the October Product Engineering Number of *American Machinist*.

An analysis of these comments reveals that many advantages are realized with flange mounting, whereas nearly all the disadvantages cited are due, not to the mounting itself, but to a lack of standard mounting dimensions. If motor manufacturers would create and follow such standards many more flonge mountings would be employed.

Nobody contends, of course, that base-mounting should be abondoned, but rather that the flange type is preferable in many instances. The advantages cited in favor of flange mounting include:

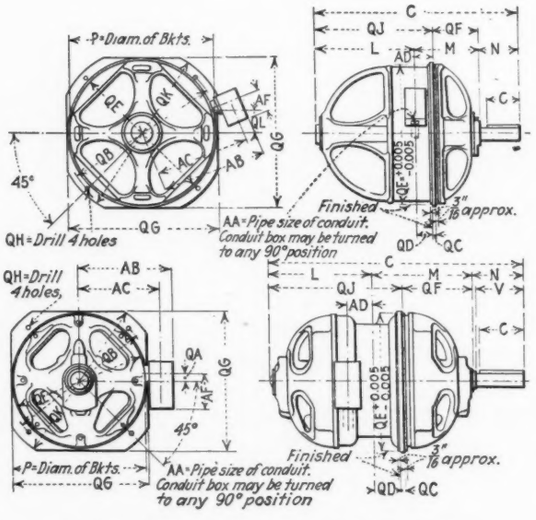
1. Improved appearance of the finished machine. The motor looks as if designed as an integral part of the machine, not as if added as an afterthought.
2. Compact arrangement, often reducing the floor space required.
3. A more rigid mounting. Overhanging brackets are avoided.
4. A considerable saving in the combined weight of machine and motor.
5. Less expense, since a separate bracket is not required.
6. Correct alignment is readily secured, especially if the flange of the motor or the machine frame is recessed to pilot the mating member.
7. Attachment is more easily made, without shimming or other adjustment.
8. Often better protection against oil, chips, and dirt is afforded.

Against these advantages, not all of which are realized in every installation, of course, are the disadvantages arising from lack of standardization as between makes. This requires machine builders to have a variety of connection flange patterns so that the customer, if he desires, may have a particular make of motor applied. One pertinent comment on this point, which motor manufacturers would do well to heed, comes from the chief engineer of a large and prominent machine builder, who says:

"At the present time, we do not build any machines using flanged type motors. We would, however, like to use this type of motor and undoubtedly would use it if the flanges were standardized and motor having the flange could be obtained from the motor manufacturers. Our policy has been to allow the customer to specify the make of motor he desires. If we should use a flanged-type motor and still allowed the customer to have the same option, we would require hundreds of flange patterns."

Much the same might be said in reference to base-mounted motors and brackets for them. Although some steps toward standardization of bases, mountings and shaft heights have been initiated, many special brackets still are required for such motors.

Today flanged motors usually cost more because they are considered "special" and are made in smaller quantities. This disadvantage would be offset quickly, however, if standardization brought larger demands, for there seems to be no inherent reason why a



OUTLINE drawings showing the mounting dimensions standardized on interchangeable Westinghouse a.c. and d.c. flanged motors

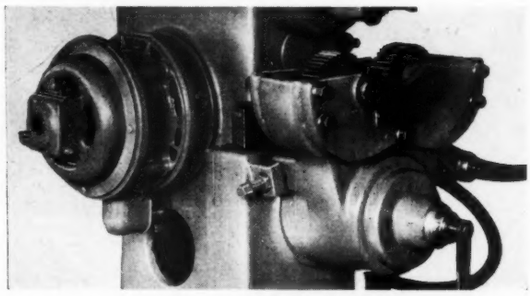
By HERBERT CHASE

Associate Editor

This, the second of a series of articles on the flange mounting of of motors, deals exclusively with American practice in machine tools. In a later article examples of similar mountings on other types of machines will be given. Readers having experience with such applications are invited to submit drawings, photographs, and other data

flange should cost more than a pedestal. It may even cost less. Moreover, the saving resulting from elimination of a bracket often more than offsets the slightly higher present cost of flanged motors.

Thus it appears that both the engineering and economic advantages of flange mounting outweigh its disadvantages, in cases where flanged construction is applicable. Adherence to the base type in such cases seems to be largely a matter of habit, providing the

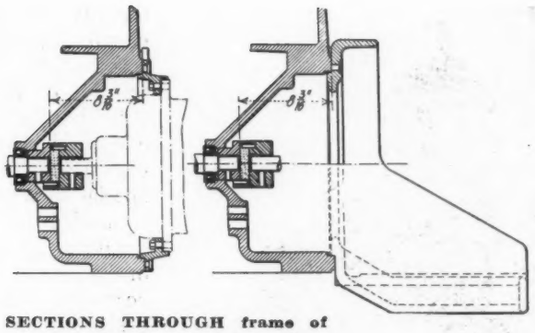


THE FLANGED MOTOR drives direct to a worm, in The Cincinnati Shaper Company's gear burnisher

relative difference in market availability is disregarded. Strangely enough, however, even this habit usually is brushed aside when it comes to using a vertical shaft motor. "There," as one engineer put it, "flange mounting is the logical solution." But would it not be equally "logical" to employ a vertical bracket to mount a foot-type motor, as to use a horizontal bracket when the same motor is horizontally mounted? In the last analysis flange mounting is quite as logical whether the motor is vertically or horizontally disposed.

Before considering specific applications of flanged motors to American machine tools, the following factors that make for success in such mountings, pointed out by Mr. Ray Millholland, of the Millholland Sales & Engineering Company, as a result of his experience with this type, are deserving of note:

1. Proper protection from dust and chips.
2. Proper cooling or ventilation.



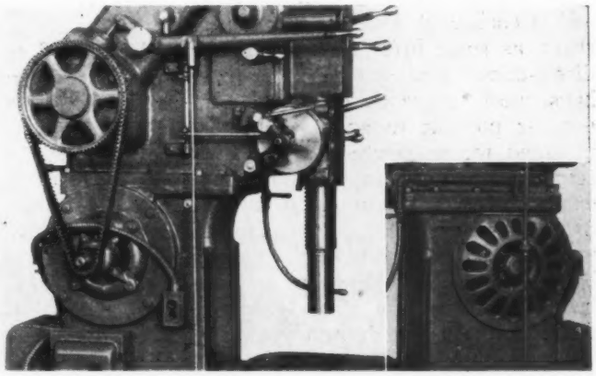
SECTIONS THROUGH frame of Gould & Eberhardt shaper, illustrating method of mounting motors by foot or flange

3. Accurate balance of rotating parts to prevent vibration and its transmission to the frame and tools of the driven machine.
4. Minimum overhang of motor.
5. Bearing design such that the motor will run in any position without even a slight change in its construction.
6. Ample power to drive the machine even though tools may be dull.

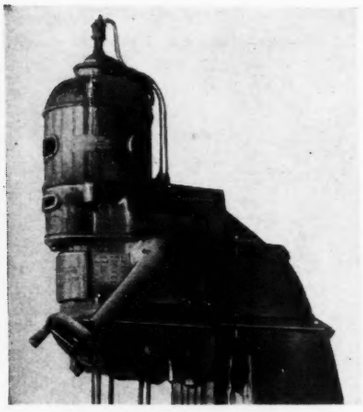
While all these points are well taken, they appear to apply with almost equal force also to base-mounted motors carried on the frame of the machine tool, although, in the latter case there may be slightly less transmission of vibration. It is just as poor practice to employ a bracket with excessive overhang as to overhang the motor unduly.

An excellent comparison as between flange and base mounting is afforded by the accompanying cuts of Gould & Eberhardt shapers one of which has a flange-mounted and the other a foot-mounted motor. As Chief Engineer W. F. Zimmermann of this company points out, "The flange-type mounting is preferable, from the standpoint of attaching, but unfortunately all motors cannot be mounted in this way, because there is no part of the motor housing that can be machined so as to centralize the motor and at the same time secure it to the attaching plate."

A motor built with an integral machined flange, of course, avoids this disadvantage, and such motors are available today although the flanges are not standardized. One such motor is shown in one of the drawings of the Gould & Eberhardt installations. "The flange-type is the neater mounting," continues Mr. Zimmerman, ". . . and by centering some portion of the motor



TWO VIEWS of Barnes drill, showing location of the flanged motor inside of the column and provision for ventilation



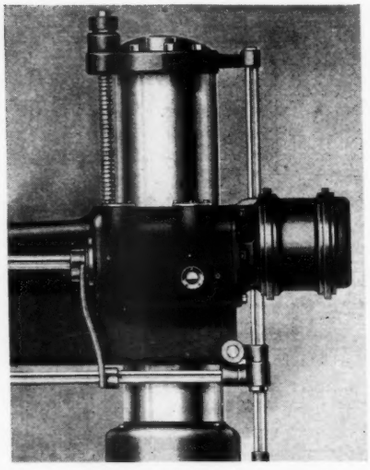
MOTOR MOUNTING on the Pratt & Whitney jig borer

frame, there is very little difficulty in attaching as compared with the foot-type mounting."

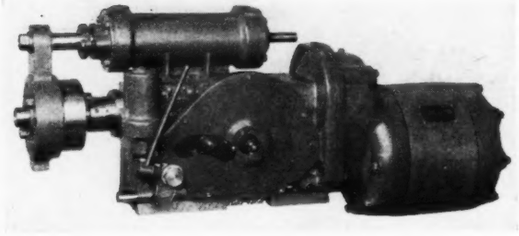
A flexible coupling, shown in the drawing, connects the motor shaft and the driven shaft of the machine, and permits of slight misalignment of the two shafts. When a pulley drive is employed in place of a motor drive, the driven shaft continues through a separate flange that forms a housing for the Timken bearing, which is moved from the position shown in the motor-drive applications. This arrangement apparently meets an objection raised by another engineer to the effect a machine equipped for flange motor drive is not readily adapted to pulley drive. Doubtless this is true in some cases, but the substitution of a flange containing a bearing, for the flange of the motor seems to afford an easy solution of this problem.

Not only can machines designed for flanged motor drive be adapted to belt drive, but flange-mounted motors can be arranged to drive the machine by belt, chain or gearing as desired. Their use by no means is confined to machines in which the work spindle turns at motor speed and is connected direct to the motor shaft, as some infer, although such direct-drive applications are, perhaps, most frequently employed. It even is possible to apply a flange-mounted motor where a change in center distances is required, as, for example, for tightening chain or belt drives. Such a motor can be adapted to be turned about one of the flange bolts to alter center distances, or can be mounted upon a slide arranged for locking in the desired position.

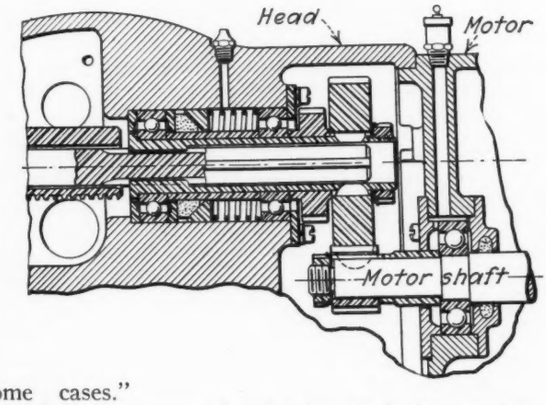
An example of an application of flanged motor in which the drive is direct to the worm of a gear reduction unit is shown in the cut of the gear burnisher made by the Cincinnati Shaper Company. In this instance, in order to realize the advantage of flange mounting, the machine builder has removed the bracket and the bearing on the drive end of the motor and has substituted a special bearing and a casting which is bolted to the machine. "This mounting works out nicely on this machine and makes a very neat appearance," writes Frank H. Pfefferle, designing engineer of this company. "One objection, however, is that a different flange casting is required for mounting practically every different make of motor. This even applies to a.c. and d.c. motors of the same company make in some cases."



MUCH WEIGHT is saved by using a horizontal flange-mounted motor on this Cincinnati-Bickford radial drill



HEAD with flange-mounted motor as used on Millholland drills



ANOTHER APPLICATION of flanged motor as employed on Kingsbury drill heads

In justice to motor manufacturers it should be said that at least one of them, the Westinghouse Electric & Manufacturing Company, has standardized a ball bearing and a sleeve bearing series of flange-mounted motors arranged in four groups and covering a wide range of power. Each frame in an a.c. group of this make is interchangeable in mounting dimensions with every other frame in that group and with the frames of motors in the corresponding d.c. group. The dimensions involved in this standardization by a single company are indicated in a cut giving outline drawings of these motors. It is a significant fact that, according to C. E. L. Dapprich, general engineer of the Westinghouse Company, such interchangeability is readily accomplished by the use of flange mounting.

One neat method of applying a flange-mounted motor to a production drill press is shown in illustrations of the Barnes drill. In this case the motor is housed within the column of the machine, yet there is ample provision for ventilation. In this instance, if the machine is ordered for belt instead of motor drive, a plain column is substituted for that shown.

An interesting application of a vertically mounted flanged motor is that employed on the Pratt & Whitney jig borer. In this installation the lower end housing of the motor is a special casting which serves also to enclose the reduction gears in the head of the machine.

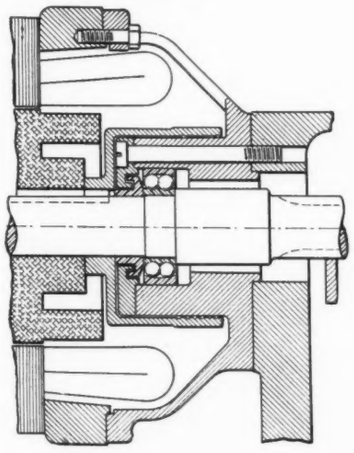
As to the use of flange-mounted motors on radial drills, after reading the article dealing with foreign practice in this respect R. N. Piper of the Cincinnati Bickford Tool Company, writes, in part, as follows:

"There can be no doubt of the

desirability of many of the machine tool applications of flanged type motors but the wisdom of some of the European examples is to be questioned. In bringing the source of power close to its point of use, several complications and disadvantages seem to have been overlooked. Placing the driving motor on the head increases vibration and adds the weight of the motor, of speed reduction gears and of the reversing clutches, thereby increasing deflection of the arm, and wear of gibbing and also making it difficult to traverse the head."

These disadvantages are either eliminated or reduced by mounting the driving motor on the arm at the opposite side of the column from the head. A foot-mounted motor can be employed in such an installation

HORIZONTAL MOUNTING of flanged motor on an internal grinder



but in that case a heavy and expensive bracket is required. Much weight can be saved and the cost and the space required can be reduced by employing a flange-mounted motor arranged as shown in the cut of the Cincinnati Bickford drill.

Millholland drilling, milling, and tapping units employ the flange mounting shown in an accompanying cut. This unit, designed and built in the Millholland plant, runs at any angle from horizontal to vertical.

A somewhat similar unit is employed by the Kingsbury Machine Tool Corporation in several forms of drilling machines, the Holtzer-Cabot motors, both a.c. and d.c. types being interchangeable. Chief Engineer G. Swahnberg of the Kingsbury Corporation states that the primary reason for using a flange-type motor was to obtain a small, compact, and self-contained unit. In the single-spindle drill press built by the same company, a belt drive with an idler is employed to facilitate speed changes, and a small pulley at the lower end of the motor shaft drives a coolant pump.

A design furnished by F. A. Firnhaber, machine designer of the Landis Machine Company, but applying to an internal grinder formerly made by another concern, is illustrated in an accompanying cut. Originally the motor was mounted on a separate pedestal and drove through a flexible coupling but the design shown was found to reduce cost, save floor space and decrease the number of parts, besides making the machine self-contained. The motor was purchased minus one end-housing and the adapter flange shown was substituted to support the stator. The rotor, with its extended shaft was mounted in self-aligning ball-bearings. Trouble at first encountered from vibration soon was overcome with better balanced rotors.

An unusual motor mounting arrangement is that in the horizontal disk grinder put out by the Porter-Cable Machine Company. In this case the foot-type motor is placed

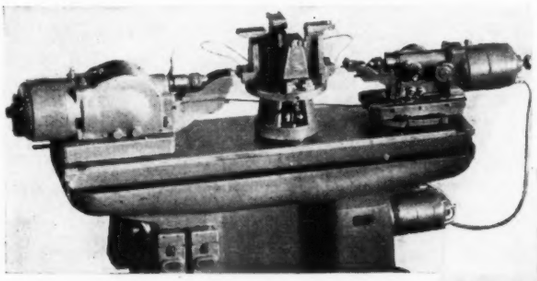
A DOUBLE FLANGE mounting is employed on this Porter-Cable disk grinder

with its shaft vertical and its two end flanges are bolted up so that the motor forms a part of the column of the machine, while the motor base serves as a support for a switch.

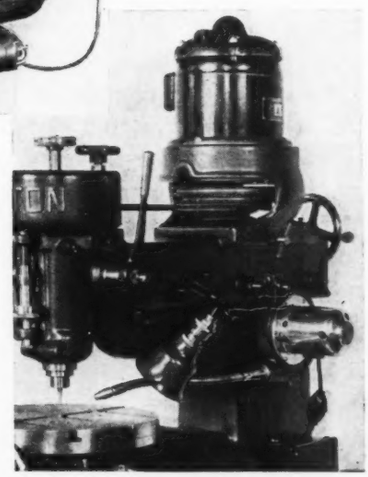
Flange mounting does not always involve having a flange cast integral with the motor. In the High Speed Hammer Company's sensitive drill for example, the "standard" motor employed is a footless type with a portion of the frame ground to fit into the recessed end of a flanged tubular base, affording a rigid mounting.

Similar in certain respects is the neat arrangement of the ¾-hp. ball bearing motor on the George Gorton Machine Company's small vertical miller. In this instance, however, the motor is placed on top of the machine with the four-step V-groove pulley below. The motor is not flanged but, in effect, is provided with a flange that takes the form of a split ring machined inside to fit over the motor frame and outside to fit into a recess of the supporting bracket. This bracket forms part of a slide easily moved and locked when the belt is to be tightened. A separate motor flanged to the casing of a small blower arranged below chips off the work also is fitted, as shown in the illustration.

Numerous other examples of flanged motor mounting on American machine tools could be cited. Enough has been said, however, to indicate that this type of mounting is not only feasible, but presents enough advantages to warrant increasing use as well as the preparation of standard mounting dimensions to facilitate wider application.



THREE FLANGED MOTORS are used on this Kingsbury drilling machine



NEAT VERTICAL motor mounting on the Gorton milling machine. The motor bracket is slidable to adjust belt tension

PRODUCT ENGINEERING

Editor: KENNETH H. CONDIT

February, 1930

For What Do Buyers Look?

MECHANICAL performance of a machine is what apparently sways buyers, not price nor the standing of the firm building the equipment. This was shown by the answers to twelve questions as to just what most influenced their decisions in buying machinery which were asked state and government purchasing agents and contractors in every part of the country by a committee of the American Road Builders' Association. The questions bore on the purchase of more than ten million dollars' worth of machinery annually, and included such points as the financial standing of the firm, capacity of the plant, and price, as well as the mechanical details of the equipment.

Seventy-six per cent of all replies placed "Your own past experience with similar machines" as the first consideration. The second in importance was given as "Experience of others with similar machines." The third on the list of answers was "Performance record of the equipment." Contrary to what is generally believed, the supply of repair parts played only a small part in the choice. Only three per cent of the answers rated the financial s anding of the manufacturer as of importance in their purchasing consideration.

It is very evident, therefore, that the users of machinery are demanding performance. It makes little difference to them whether the machine is built in a million dollar plant or in a little job shop. They are not interested in repair parts—they want performance without tinkering. It all comes back then to the design. The machine must be well designed to perform, and it must be of good materials that will give service over a reasonable period.

Too Much Specialization

ENGINEERS who, of necessity, require intensive specialization in their work, should not forget that tomorrow is likely to demand, perhaps of them, an entirely different class of special effort. This is a day of rapid changes, both in products wanted and in the classes of engineering needed to design and produce them.

Following one specialty without maintaining some contact, at least with related lines of work, leaves any man in poor shape to face a new set of conditions. It also narrows his point of view and prevents him from benefiting by the experience of others and by new developments in different fields. It is likely to make a new engineering connection more difficult to secure, if and when one is wanted, partly because the number of possible openings is correspondingly restricted.

It therefore behooves engineers to maintain contact with a reasonable diversity of engineering work. Few things can help them more in doing their present jobs better than learning how other engineers have done their jobs well. Reading of publications with well-selected engineering articles and following or taking part in the activities of engineering societies are among the best ways an engineer can keep himself well informed and up-to-date.

■

Modern Art in the Product

DESIGNERS who are out for appearance and art in their product must approach the so-called modernistic trends with caution and with a great deal of common sense. There is much of promise in some of this art, and much to be questioned in some more of it. Some designers are even drawing quite a distinction between the meanings of "modern" and "modernistic" with disparagement to the latter. At the annual meeting of the American Management Association E. Grosvenor Plowman made the statement that the extreme examples of cubism and geometric kaleidoscopes are unintelligible to the public mind and are nauseating to possessors of good taste. C. M. Hoke, of the Jeweler's Technical Advice Company, goes farther and says that some of these examples of the "modernistic touch" have brought sharp distress to jewelers.

It all comes down to the point as to what is a meaningless fad and what is a real step in progress. There is something worth while in modern art tendencies, especially in the school of modern art that is looking to straightline effects and simplicity. Some beautiful effects in radio cases and in other products have been produced in this way, and the simple geometric combinations should also lend themselves readily to machine elements. But it is questionable if the distorted shapes and fantastic ornamentation sometimes called "modernistic" are more than a revival of primitive art that will pass away like any other fad. The pendulum has probably swung too far over. It will swing back and eventually center itself to show a normal line of progress.

■

Standards for Specification

A STUDY of the specifications issued by a number of different companies shows that they apparently do not agree within a wide range on the meaning attached to various more or less common technical terms. It is probably for this reason that some government specifications embody definitions of the terms used.

New methods of testing and new physical relationships, constantly being discovered by scientists, change the significance of former tests and their results. Thus, when specifying certain physical properties, the engineer should, in many cases, also specify the test method by which the specified requirements are to be checked. But to do this would require pages to specify something which should take only a line, and engineers would soon establish an array of different testing methods.

Fortunately the engineer has at his command a relatively simple way to meet his problem. Several of the recognized engineering societies have established "standards" covering both metallic and non-metallic materials, heat-treating, testing methods, and nomenclature, and the whole thing clears through the American Standards Association.

Every engineer will do well to specify the recognized technical society "standards" pertaining to his problem, thus not only greatly simplifying and strengthening his specification, but also adding weight to the established standards.

The Product Engineer's Interest in Equipment Replacement

IT IS becoming more and more evident that equipment modernization is going to be advanced during the weeks directly ahead. Important organizations are swinging into line to add their effort to the drive to get action. Is the product engineer lifting his voice in the executive councils that are considering modernization?

A new product, with more popular appeal, may mean much to the sales department. If that department is given a product that it can push enthusiastically, it may well demand larger production from the manufacturing department, which in turn will probably have to broaden the scope of its plan for equipment replacement.

Many a product engineer has been slow to take the aggressive, largely because of his training and natural inclination, but here is one time where he must forget himself and make himself heard.

▼

New Designs for Old

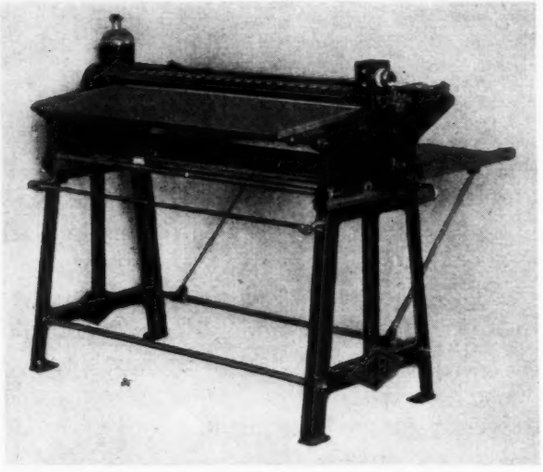
NO LESS than five new designs of electric waffle irons were placed on the market last month! They incorporated new features—daintier lines, better die-castings, fancy finishes, and two with automatic timing devices. But no designer as yet seems to have done anything for the hungry guests at the Sunday night waffle supper who wait the long minutes until everyone is served by the hostess!

The automobile people have eliminated the chauffeur, and want to sell a car to each member of the family, so why not a waffle iron with automatic control for each supper guest, or each pair of guests? Why not forget the conventional round design that appears in every one of the above five, plan for an iron that will plug into a loop of wire around the table at intervals of every two seats, and that will produce two conveniently shaped waffles that can be eaten while the iron cooks two more? And couldn't this individual iron have places in front for individual batter, butter, and syrup? Could the market be quadrupled by designing something entirely new?

NEW MATERIALS AND PARTS AND ✦ ENGINEERING EQUIPMENT ✦

"BW" Direct Printing Process and Equipment

BLACK-LINE positive prints with white backgrounds can be produced directly from tracings as quickly and economically as blue prints and without the aid of a negative and the necessity for the usual washing and drying operations by means of the "BW" process, according to an announcement by the Charles Bruning Company, Inc., 102 Reade St., New York, N. Y. The black lines of the tracing are reproduced evenly and cleanly, even though they are as thin and fine as ordinary map contour lines. Such clarity of reproduction, coupled with the clear white background, affords better visualization of the drawing, minimizes eyestrain, and lessens the chance for error. In addition, the white background is of value for checking and making notes. Tests have shown that the black lines will not rub off nor fade, nor will they run if the print is watersoaked.



Bruning No. 2831 "BW" Sheet Developing Machine used with the "BW" process of making black-line positive prints on white backgrounds

The sensitized paper used for this process is furnished in the usual sizes —30-, 36-, and 42-in. rolls of 10, 25, and 50 yds. There are two weights available, medium and thin, also one weight of cloth. The "BW" sensitized paper and cloth are claimed to have the same printing range as rapid blueprint paper.

To make a print, the tracing and sensitized paper or cloth are run through a blueprinting machine in the usual manner. Instead of using a developer, followed by washing and drying operations, as in blueprinting, the exposed paper may be run through either a developing attachment installed on a blueprinting machine or through a separate machine designed for the developing process only. In either case, the exposed print is run through rolls, one of which dips into a shallow trough of developing solution. The film of solution on the roller is not sufficient to wet the paper appreciably, so that after leaving the solution roll it is quite dry. The solution in the trough is kept at a constant level by means of a syphon on a bottle placed at the end.

Three types of apparatus are available for developing. The first, No. 2830, is made to fit continuous blueprinting machines, and is supplied with all necessary parts. It consists simply of the rolls, developing trough, solution bottle, and necessary supporting members.

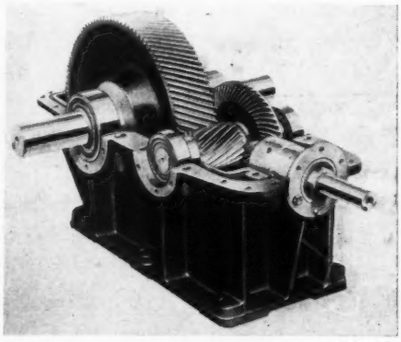
The No. 2831 sheet developing machine, illustrated, is designed for rapid developing of both sheets and continuous yardage. The sheet or continuous yardage is fed over the working table and through the developing rolls. It next passes between two sets of fabric belts situated over an electric heating plate. Two heating elements are contained in this plate, and these can be turned on and off separately or together. After passing between the belts which hold the print flat, the print drops off on a receiving board at the back of the machine. A $\frac{1}{8}$-hp. motor furnishes drive through a clutch to the developing and conveying-belt rollers. A single electrical snap button is provided by which four different conditions of operation may be had. If it is snapped to the first position, the motor starts; at the second position one unit of the heating element is turned on; in the third position the second unit is turned on; and in the fourth position the heat is turned off and the motor stops.

The last type of apparatus is the No. 2833 portable hand outfit, which can be transported anywhere, and which is intended for use where only an occasional print is required. The exposed print is merely pulled through the rollers by hand, and it is developed instantaneously as it passes over the developer roller.

■

Falk Right-Angle Drive

TO SUPPLEMENT its line of parallel shaft drives, the Falk Corporation, Milwaukee, Wis., has brought out a line of right-angle speed reducers, which includes both the horizontal and vertical shaft types. One feature of the right-angle drive is the combination of single helical and spiral



Falk Right-Angle Drive, which is available in sizes from $\frac{1}{4}$ hp. at 100 r.p.m. to 565 hp. at the same speed

bevel gears. It is claimed that the use of a single helical gear for the final reduction makes the drive easier to assemble and that the combination with a spiral bevel gear makes a quiet, cool-running reducer, which has an initial efficiency of 95 per cent.

The reversible construction of the gears and shafts is another feature. If the gears become worn, the shafts can be turned end for end to permit using the opposite and unworn sides of the teeth. The lubricating system is simple and self-contained. A continuous splash keeps a film of oil on the faces of the gear teeth at all times.

Ratings of this line of right-angle reducers range from $\frac{1}{16}$ hp. per 100 r.p.m. on the smallest unit to 565 hp. at 100 r.p.m. on the largest size. Reduction ratios are from 15:1 to 518:1. A complete line of welded-steel motor beds has been developed.

■

"Oilrite" Non-Friction Piston

WHEN a cold motor is started, the pistons expand almost at once, causing much friction between the pistons and the cylinder walls that have become dry while the motor was standing idle. In order to do away with excessive wear that occurs in aluminum alloy pistons under such conditions, the National Alloys Company, 2118 Woodbridge St., Detroit, Mich., has announced the "Oilrite" non-friction piston, which is self-lubricating and designed to lubricate the cylinder wall thoroughly on the first stroke of the piston. It minimizes friction and wear generally encountered on thrust skirts, and provides a better compression seal for starting.

The expansion difficulties inherent in all aluminum pistons are minimized by means of two expansion "U's" provided in each skirt strut. These are designed to compensate for the expansion of the struts and dissipate the heat conducted from the head of the piston through the struts to the skirt. By this construction, it is claimed that the skirt expansion of these pistons is reduced to the equivalent of that in cast-iron pistons, and that "Oilrite" pistons may be fitted to the same clearances as cast-iron pistons. The specially designed oil reservoirs in the piston provide lubrication of the cylinder wall the moment the piston is moved, and also provide automatically a sealing film of oil for the first compression stroke, which makes for easy starting without excessive choking of the motor. These "Oilrite" pistons are manufactured in standard sizes for all makes of motors.

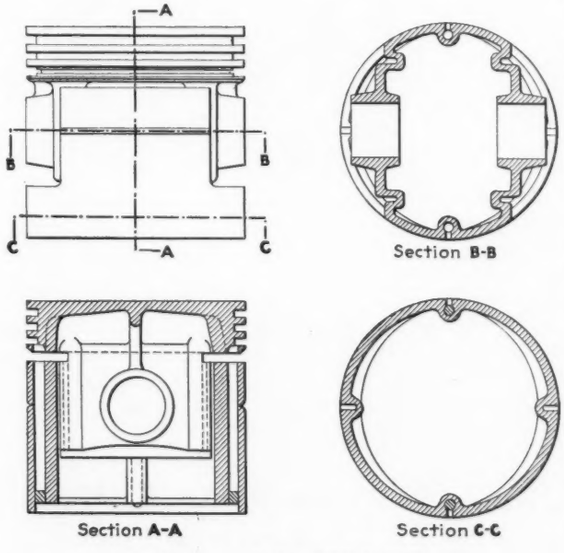


Diagram of the "Oilrite" Piston

B-B shows expansion U's. Section C-C Shows Expansion of "Oilrite" piston and location of oil reservoir. Section Section A-A and the diagram above it show construction U's in skirt ring

■

Morse Flexible Couplings

THE FEATURE of the flexible couplings announced by the Morse Chain Company, Ithaca, N. Y., is that they consist of two sprockets encircled by a Morse silent chain. This chain is held in place by a guide groove in one sprocket, while the other sprocket is free to float under the chain. The full floating principle employed relieves the adjacent shaft bearings of possible thrust strains by permitting freedom of end play. In addition, the flexibility of the chain relieves the coupling pinions of a great deal of the shock and binding that accompanies starting.

The chain links are hardened and drawn to give minimum wear with extreme toughness without becoming brittle, and these links run on casehardened pinions. Rockers and seats are also case-hardened.

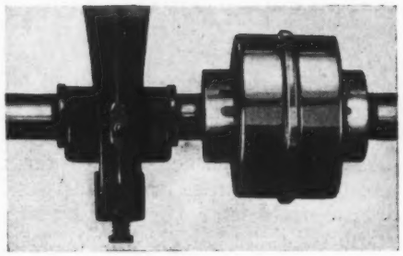


Fig. 1—Morse Flexible Coupling equipped with spun metal cover to retain lubricant

Inaccuracies of alignment of the connected shafts are taken care of by the flexibility of the chain. Small clearances between the pins and the links, and between the links themselves, permit sliding of the links relative to each other. Also, relative motion is possible between the sprockets and the chain, which is self-centering due to centrifugal force. Some couplings have shearing pins to prevent overloading of the machine. Other combinations of couplings with clutches, clamp hubs, and spring sprockets have been worked out for special cases.

In Fig. 1 is shown a complete coupling with an oil-retaining, spun-metal cover, whereas Fig. 2 shows the usual assembly of the coupling as frequently run without the above cover. In the usual installation of this spun-metal case, the case is

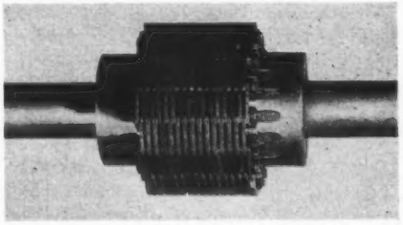


Fig. 2—Assembly of Morse flexible coupling

separated from the chain by a layer of felt whose purpose is to hold oil and to insure silent operation. The metal case is self-centering.

■

"Sumetized" Bronze-Lined Steel-Backed Bearings

THE Sumet Corporation, Buffalo, N. Y., announces a line of bronze-lined and bonded bearings and bearing materials under the name of "Sumetized." They consist of a steel-backed bearing with a bronze liner intimately bonded to the steel. The bonded liner can be finished as thin as 1/62 in., and the bearings in

NEW MATERIALS AND PARTS

any ordinary commercial diameter. The Sumetized bonded bronze is essentially a high-lead bronze bearing with the tensile strength for a given wall thickness greatly increased by the steel back. The bond between the bronze and steel is claimed to be intimate so that no sliding or breaking off is possible.

■

Improved Johnson Clutch

TO INCREASE the wearing properties of this clutch, nickel steel fingers, otherwise known as clutch levers or toggle levers, have been substituted for the carbon-steel, drop-forged fingers formerly used. The clutch is manufactured by the Carlyle Johnson Machine Company, Manchester, Connecticut. Other improvements are: a method of locking the adjustment screw so that it cannot come loose under vibration; replacement of the tool steel adjustment blocks with ones of chrome-nickel steel, and lubrication by the Alemite system.

■

Rawplug "Crowners" and "Lok-Crowners" for Concealing Screw Heads

UNSIGHTLY screw heads, bolt heads, and nuts may be covered neatly with a suitable "Crowner" or "Lok-Crowner," both of which are small ornamental caps. The former are used principally to enhance the appearance of the product, whereas the latter, in addition to this feature, are capable of preventing loosening because of a special lockwasher construction. These specialties have been placed on the market by the Rawlplug Company, Inc., 66 West Broadway, New York.

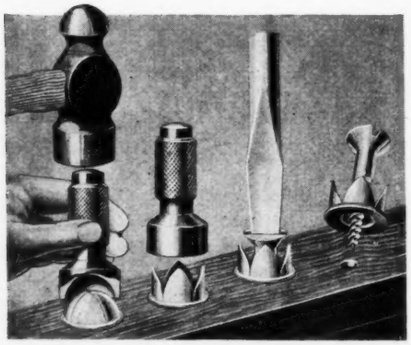


Fig. 1—Illustrating the simple operations required for placing the "Crowner" cap on a screw, to do away with unsightliness

Fig. 2 — A "Lok-Crowner" combines all the features of a "Crowner" and has a lockwasher as well

Crowners, in addition to concealing the heads of exposed screws, permit the use of stronger and less expensive iron screws to replace brass, bronze and specially plated screws. They prevent tampering with screws and easy removal of fixtures and devices, and reduce the cost of assembling products by simplifying the design. As will be seen from Fig. 1, they can be applied quickly. They eliminate torn garments and injuries caused by burred screw slots. The cap will not rust and may be made to match any finish desired. It is available for every size screw, bolt, and nut.

As shown in Fig. 2, the Lok-Crowner combines all the features of the Crowner and prevents the loosening of nuts from vibration, being provided with a special lockwasher. Costly and complicated methods of hiding screws are eliminated and the lockwasher is completely covered, preventing rust or stain. The Lok-Crowners are also made for every size bolt.

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"Thyrite"—Both an Insulator and a Conductor

A MATERIAL that is both a conductor and a good insulator of electricity has been announced by the General Electric Company, Schnectady, N. Y. This material has the property of increasing or decreasing its resistance as the voltage is increased or decreased. The relationship does not depend on the rate of voltage application and may be made to repeat itself indefinitely without change. The resistance and current relationship follow a definite law. This change in resistance is such that the current increases 12.6 times each time that the applied voltage is doubled.

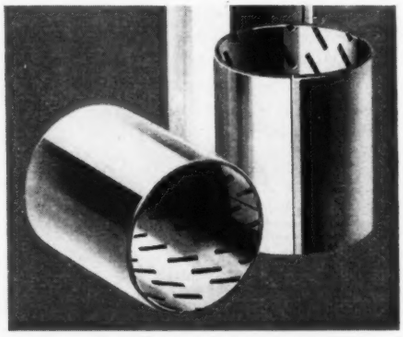
"Thyrite" resembles black slate in color. It possesses molding properties similar to those of dry-process porcelain. In manufacturing it, the material is molded to the shape required and the contact surfaces are coated with metal by the Schoop metal-spraying process.

This material is for use in lightning arresters and other protective devices. In discs 6 in. in diameter by $\frac{3}{4}$ in. thick, it has a resistance of 50,000 ohms when 100 volts are applied to the parallel faces, but the resistance decreases to less than $\frac{1}{2}$ ohm when the voltage is increased to 10,000 volts. These discs of Thyrite will carry lightning discharges having currents as high as 30,000 amp. without distress. It is possible to use the material successfully on any a.c. or d.c. circuit; it is necessary only to supply a proper amount of material so that it will not become overheated.

■

Johnson Self-Lubricating Bronze Bearing

A SELF-LUBRICATING bronze bearing has been announced by the Johnson Bronze Company, New Castle, Pa. This bearing provides for a uniform area of bearing surface on the pressure line, and insures an efficient distribution of lubricating compound. The compound used is also a development of the above company. As shown in the illustration, the grooves are short indentations, and they are cut at an angle of 30 deg. with the horizontal axis.



Johnson Self-Lubricating Bronze Bearings

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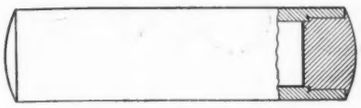
Victor Piston Pins With Non-scoring Plugs

A FULL-FLOATING piston pin, illustrated herewith, has been placed on the market by the Victor Piston Pin Company, Indianapolis, Ind.

NEW MATERIALS AND PARTS



Victor Full-Floating Piston Pin with Locked-in Plugs

Plugs of a soft alloy are fastened into the pin at both ends. In the manufacture of this pin, the plug recess is made in one operation, its depth below the bore of the pin being only about one-half what is ordinarily allowed for plugs that are made a press fit in a straight recess. Machined plugs are inserted into this pin and light pressure is applied, either by means of a hammer or a press, this pressure causing the plugs to expand into the groove. These soft plugs do away with scoring of the cylinder walls.

REVIEW OF RECENT PATENTS

Parts and Mechanisms

A transmission comprising driving and driven shafts, a differential member, selective gears with clutch elements on the differential, and means for driving at various speeds is the subject of patent 1,726,246 granted to Byron Stevens, of Oakland, California.

Patent 1,726,279, granted to Walter W. Werner, of Detroit, Mich., covers a device for winding coils of tubing, and comprising a spool, adjustable grooved bars transversely positioned thereon, and other co-operating parts.

Carl Morey, Big Rapids, Mich., has been granted patent 1,728,246 on a curvature control mechanism for metal-forming machines, involving the use of complementary eccentric driving members.

To the R. K. LeBlond Machine Tool Co. has been assigned patent 1,723,347, on a chucking device for crankshafts, comprising, among other parts, pivoted means to clamp about a pin, and additional means to grip the cheek portions of the crankshaft in sequence.

Materials

An alloy comprising 40 to 80 per cent of nickel, 1.5 to 10 per cent of silicon and the balance principally copper, and having the ratio of nickel percentage to silicon percentage falling within the range of 7 to 28, is the subject of patent 1,732,327, assigned to the Electro Metallurgical Company.

Arthur James Line, Edgbaston, England, has been granted patent 1,732,727 on a solder for aluminum and its alloys, consisting of a composition of approximately 3 parts, by weight, of silver and approximately 12 parts, by weight, of aluminum.

To the Vanadium Corporation of America has been assigned patent 1,732,915 on a steel densifying and scavenging alloy, containing aluminum from 5 to 30 per cent; silicon about 60 to 90 per cent; the remainder being principally iron.

An alloy steel containing from 0.10 to about 1 per cent of carbon, from about 8 to about 18 per cent of chromium, from about 0.9 to about 1.3 per cent of manganese, from about 0.08 to about 0.15 per cent of phosphorus, and from 0.05 to about 0.15 per cent of sulphur, is the subject of patent 1,730,780, assigned to the Crucible Steel Co. of America.

PUBLICATIONS

Ball and Roller Bearings. S. K. F. Industries, Inc., 40 East 34th St., New York, N. Y., has recently released several publications concerning some of the engineering phases of its products. Bulletin No. 205 covers engineering data sheets giving load ratings and dimensions for radial, angular contact and thrust ball bearings, as well as cylindrical and spherical roller bearings. In addition, there is information on shaft and housing fits. Bulletin No. 206 covers the lubrication of ball and roller bearings; charts are included giving specific information according to application. Bulletin No. 207, entitled "Engineering & Design," presents a summary of anti-friction bearing applications brought up to date. Much space is given to the design of ball and roller bearings.

Controller for Printing Presses. The Monitor Controller Co., Baltimore, Md., has published bulletin No. 115 on its automatic magnetic-reversing, printing-press dynamic braking controller for d.c. motors. It contains a complete technical description of the various component parts. The catalog contains seven 11 x 8½-in. pages.

Flexible Couplings. The Diamond Chain & Manufacturing Co., Indianapolis, Ind., has published a booklet on "Diamond-Clark Flexible Couplings," showing the construction of and giving the uses for this roller-chain type flexible coupling. The pamphlet contains sixteen 9x6-in. profusely illustrated pages.

Motors, Polyphase. The Century Electric Co., 1806 Pine St., St. Louis, Mo., has issued a circular on the type SC, multi-speed, normal starting current, squirrel cage induction motors. It discusses the technical features of the design.

Nickel and Monel Metal in Power Plant Equipment. The International Nickel Co., Inc., 67 Wall St., New York, N. Y., has published a booklet which traces the results that have been obtained in many industries with the use of rustless metals like nickel and Monel metal. It contains reprints of advertisements of manufacturers of power plant equipment in whose products these materials have found application and the reasons therefor. The booklet contains 48, 11 x 8½-in. pages.

Screw Thread, Dardelet. The Dardelet Threadlock Corporation, 120 Broadway, New York, has published a booklet, entitled "Dardelet, The Self-Locking Screw Thread," which describes this thread and its properties of resistance to vibration. Many illustrations are furnished, together with a table of thread data. The pamphlet contains nineteen 9 x 6-in. pages.

Testing Equipment. The Southwark Foundry & Machine Co., 400 Washington Ave., Philadelphia, Pa., has published a loose-leaf catalog showing the various types of its testing equipment. Considerable material is given on the design of these machines and the specifications and erection requirements. The catalog contains 62, 9 x 6-in. pages.

Transmission Equipment. The Hill Clutch Machine & Foundry Co., 6400 Breakwater Ave., Cleveland, Ohio, has published Catalog 29-A entitled "Hill Clutch Power Drive Equipment," which describes the shaftings, couplings, Cleveland type oil film bearings, Cleveland type, water-cooled and heavy-duty oil film bearings, baseplates, floor standards, cast-iron wall boxes, hangers, agitator bearings, and plain grease bearings. Each part is illustrated and described, and the specifications are listed.

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A.S.M.E. Technical Committees Report. The American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y., has published a reprint of the annual reports of the A.S.M.E. Research, Standards, Safety, Power Test Codes, and Boiler Code Committees for 1928-1929, in pamphlet form for convenient reference.

Index to A.S.T.M. Standards. The American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa., has issued an "Index to A.S.T.M. Standards and Tentative Standards," as of September 3, 1929. The catalog contains 109. 9x6-in. pages.

✦ WHAT'S GOING ON ✦

Materials and Parts Stressed at Motor Boat Show

LISTENING to a demonstration of one of the ultra-modern boats at the Motor Boat Show, Grand Central Palace, New York City, during the week of Jan. 17-25, one could not but be impressed by the importance given by manufacturers to well-chosen materials and unit parts. Little was said about the boat itself—general designs are in most cases conventional and follow principles known for ages in this industry, which takes its rank with the jewelry industry as the "oldest in the world." But great stress was placed upon the incorporation of specialized mechanical units of proved value and high-grade materials, which, though more costly, give durability in service and lasting appearance. These parts are found in practically all sections of the crafts in competition with the older galvanized iron, and plated brass, bronze, and copper fittings.

EXAMPLES of alloy applications are the use of Monel metal, Everdur, and Tobin metal for propeller shafts in the better boats, Everdur bolts, nuts, nails, and similar pieces, Nirosta, chromium-plated and Monel-metal searchlights, horns and similar exposed fittings, nickel-silver trims, manganese-bronze struts and rudders, and the so-called "plastic" high-lead bronze stuffing boxes. Many fittings are die castings. Safety-first cautions have apparently hit the boat builder, and the makers of speedboats are using shatter-proof glass in the windshields to prevent injury in case of bumping against docks. This year the old-time linseed oil varnish finishes are meeting some competition from a newcomer in the way of a marine varnish put out by the Bakelite Corporation.

THE EFFORT has been generally to improve the appearance and increase the speed of the boats, while designing them for low cost to increase sales. To that end, the modern small cruiser type boat is a floating home, having full accommodation for from four to ten people for an extended cruise. Every inch of space is utilized. Comfort is gained by bettering engine performance, using silencers and mufflers, automatic pumps, partial automatic control, and by equipping the boats with every fitting of the modern home, including radios. This same tendency is carried over into the power plants. Most of the engines showed all moving parts covered, and stressed economy and neatness, as well as quiet, untroublesome, and efficient operation.

REDESIGN of the hull itself has been largely in refinements: separate crew quarters, pullman berths, ample head room, special fuel-filling methods, large storage spaces, bilge ventilation, and complete galley facilities. In general, the outstanding effort expressed at the Show was the attempt to popularize the motor boat with the great body of people who cannot afford to pay for a custom-built job. Boats nowadays are practically "fool-proof," comfortable, effective in appearance and operation, and comparatively inexpensive. They are a product of the designer's effort to give more for less.

The Month In Product Design

AMONG the types of planes exhibited at the International Aircraft Exposition, St. Louis, from February 15-23, are a dozen which have never been shown before. One of the unusual ones, according to *Aviation,* is a four-place American Eagle monoplane, designed by Stanley Wallace, chief engineer of the Wallace Aircraft Company, Inc., a division of the American Eagle Aircraft Corporation. It is of the folding-wing type.

The Driggs Skylark, creation of Ivan H. Driggs, chief engineer of the Driggs Aircraft Corporation, utilizes fabric-covered wings over stamped aluminum alloy ribs on spruce spars, the fuselage being the conventional steel-tube type, with cockpits reinforced with circular hoops of large-diameter steel tubing for safety to personnel and to eliminate weave through the portion of the fuselage where normal bracing cannot be placed. A three-engine deluxe club plane is shown by the Stout Metal Airplane Company, a division of the Ford Motor Company, fitted with complete night flying equipment, including an electric starter and a motor generator. The exterior finish, called "Bird's Eye," produces the effect commonly found on the inside of watch cases. The interior is fitted with six special reclining chairs, four of which are so grouped that a card table may be attached to their arms. A folding berth is located in the high ceiling portion of the cabin and arranged so that it may be folded up into the ceiling when not in use. Directly below this berth is a small davenport. In the after portion of the cabin is a complete kitchenette equipped with hot plates, thermos jugs, kitchen utensils, sink, and drainboard.

INCLUDED in the materials section of the exhibits is an exhibit of sand-cast, die-cast, and permanent-mold-cast parts in aluminum, sand-cast magnesium parts, and formed and fabricated sections of aluminum sheet tubing, bar, and other stock by the Aluminum Company of America. As an indication of the extent to which alloys are being used all utensils, instruments, and accessories are designed with attention to light weight and corrosion resistance.

G. M. Bellanca, designer and builder of passenger monoplanes, is now constructing a 12-passenger single-motor transport planned to give lower operating cost and higher speed. The plane is designed to show a top speed of 150 miles an hour, is built to sell for $30,000 or less, and can be operated for 50 to 75 cents a mile. It has a wing spread of 65 ft. and is modelled generally along the lines of the *Roma.* Empty it will weigh 4,800 lb. and will carry a useful load of 4,100 lb., of which 2,610 lb. is allotted to passengers and their baggage.

Other developments in the past month have been a controllable-pitch and reversible-pitch propeller for use on super-charged engines, designed for high-altitude work, which has reduced the length of run necessary for take-offs, increased the climb greatly, and improved the all-around performance in higher altitudes; also a new triangular parachute which gives more directional control than that possible previously.

Two new automobile radios are the American Bosch and the "Transitone." The American Bosch screen-grid tube

receiver is engineered for auto installations, the hand-size control unit being movable to any convenient place on the dash. A-battery current is supplied from the regular car battery, B-batteries being housed in a heavy steel waterproof battery box installed underneath the car floor. The entire outfit is shielded from external influences. The Transitone is also completely shielded. Either set may be attached without drilling the dash. Six years of research have resulted in the construction of the Utah radio remote-control device using a tiny motor of new design, said to be the first new motor produced in the last 20 years. The motor is 3 in. in diameter, ¾ in. long, is both brushless and reversible.

MANY FAILURES in the radiovision field may be traced to the use of the usual short-wave receiver, according to *Radio Retailing*. A special short-wave receiver employing a non-regenerative detector has been developed by the Jenkins Television Corporation, a.c.-operated and including its own power pack with a rectifier. It has a single tuning control, volume control, and coupling control and as a result of a special resistance network in the audio frequency amplifier, it amplifies uniformly over a range from 15- to 30,000 cycles. Three small, portable, metal units comprise the Bell & Howell "Project-o-phone" outfit for presentation of talking movies. An outstanding development of the past month has been the a. c. Pentode, or five-element tube, a kind of double screen-grid, having a screen around the plate as well as another screen between the control grid and the cathode.

Probably outstanding in the electrical appliance field, according to *Electrical Merchandising*, is the new Westinghouse refrigerator, now being marketed after twelve years of laboratory research. The motor and compressor operate in a hermetically sealed cage, with no attention from the user. A blower fan to increase the refrigerator's efficiency takes its power from the main motor by magnetic rather than mechanical means. The freezing mechanism is placed above the food compartment; the refrigerant is sulphur-dioxide.

The "Standard Royal Princess" range, put out by the Standard Electric Stove Company, is a three-plate range with a large aluminum-lined oven. The finish is white porcelain with nickel-plated fittings. The Estate Stove Company is announcing porcelain color combinations of ivory and jade green and ivory and ebony, as well as the conventional white and French gray, an indication of the definite trend toward color in the finishing of electrical accessories.

After ten years of experimenting, Leon Cammen, consulting engineer of New York City, gave a commercial demonstration of a centrifugal billet-casting machine which is claimed to eliminate the expense of removing slag from iron ore and reducing the cost of steel production between $4 and $5 a ton. The machine is similar to that used for making cast pipe, the principal difference being that the billet machine is divided into compartments.

OUT WEST the Pomona Pump Company has just finished a turbine-type pump which will lift water 864 ft. The pump weighs 48,000 lb. without the motors. Outstanding design problems in the development of the pump were the problem of lubrication and the prevention of whipping in a drive shaft of such great length. This was solved successfully by using a water-lubricated resilient type bearing. The shaft floats in a film of water and all vibrations are completely cushioned. Only one shaft is used as the separate stages drive from the same motor at the surface.

The Westinghouse Company has developed a line of 3,600 r.p.m. induction motors for high-speed work. They are small in size, require little space and the largest one built today weighs only 7,700 lb. One-piece punchings of silicon steel are used in both stator and rotor. The Southern California Edison Co. has placed an order for the first hydrogen-cooled synchronous condenser to be used west of the Mississippi. By using hydrogen instead of air as a cooling medium, approximately 20 per cent greater cooling efficiency is obtained, resulting in a hydrogen-cooled synchronous condenser about 4/5 the size of a similar air-cooled one.

News of the Metal Markets

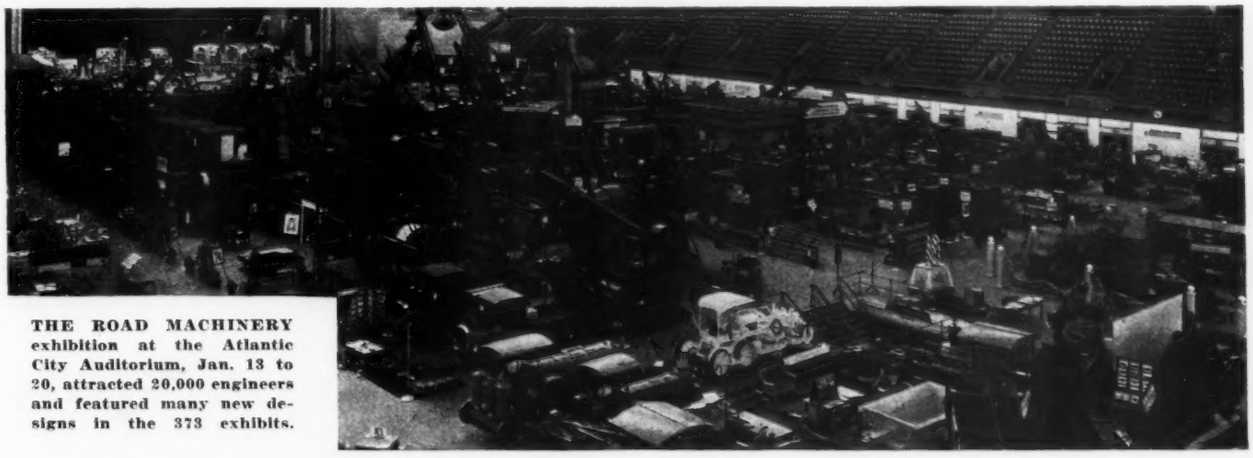
LOW ZINC PRICES resulting from the expiration of the zinc cartel and consequent unfettered producer competition may indicate cheaper brass and more of it in competition with steel. Zinc sales last month, according to *Engineering and Mining Journal*, were the largest since last March. The metal is selling for about 15 per cent less than lead now, and producers have become more or less reconciled to the change. Zinc prices have dropped a cent a pound in the past year, lead prices less than a half cent.

COPPER prices are still quiet at 18 cents a pound, delivered, where they have been since last May. Brass manufacturers, with a few orders from the automotive industry, a little public utility wire business, some fabricated plate sales, and better export business, have improved the copper market, but the price is expected to stay as it is.

SILVER seems bent to come more into the range of commercial parts plating, having fallen to a new low of 43⅛ cents recently. Demand for silver from China is disappointing to sellers, and the Indian silver corner seems to have weakened. American silver production was 2,475,000 oz. more in 1929.

TIN producers have been asked to curb their output by the Tin Producers Association with a view to stabilizing the market. Malayan production increased last year. Cornish companies are restricting output. The effect on price is problematical. This metal has dropped more than 10 cents a pound during the year. The bulk of the metal goes into "tin plate" and into bronzes, and substitutes have been well developed during the period of high prices, except for the pure tin-coated plate used for food containers.

MANGANESE prices have been forced down by sales of the Russian product. A large, accumulated stock of manganese is reported in India, and production in that country is being suspended.



THE ROAD MACHINERY exhibition at the Atlantic City Auditorium, Jan. 13 to 20, attracted 20,000 engineers and featured many new designs in the 373 exhibits.

✦ IN THE SPOTLIGHT ✦

ANDREY A. POTTER, dean of engineering, Purdue University, has been appointed a member of the A. S. M. E. Research Committee for the term December, 1929-1934, according to a recent announcement by President Piez. Dean Potter takes the place made vacant by the retirement of Prof. A. E. White, director of the department of engineering research of the University of Michigan.

MISS MARIE ROOT, manager of the Root Spring Scraper Company, supervised the company's machinery exhibit at the Road Show in Atlantic City, Jan. 13-17. Miss Root has been in charge of the plant since the death of her father 5 years ago, during which time many improvements in design of the product have been made.

PROF. CHARLES SELTON SCOTT, Yale University, was awarded the Edison Gold Medal, the highest award of the A.I.E.E., at the Institute's recent convention in New York City. The medal was bestowed upon Professor Scott for his "contributions to science in the art of polyphase transmission of electrical energy," by Professor Harold B. Smith, Worcester Polytechnic Institute, president of the A.I.E.E.

W. S. ORR and MANCE A. CRONK of the Freyn Engineering Company, Chicago, sailed on Feb. 1 on the *Bremen* en route to Leningrad, U.S.S.R., in connection with the Freyn contract with the Soviet government for iron and steel experts in engineering. WILLIAM T. MARTERSTECK sailed a week later on the *Aquitania* to join them.

GEORGE H. PALM, for the past six years engineer with the Yellow Coach & Manufacturing Co., Pontiac, Mich., has become connected, as engineer in charge of radiator construction and equipment, with the Young Radiator Co., Racine, Wisconsin.

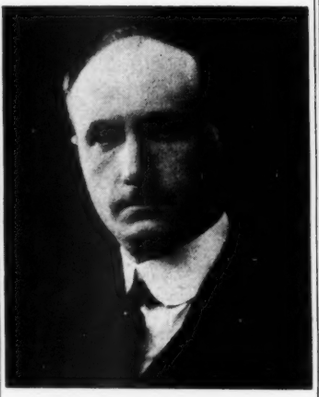
MORTIMER ELWYN COOLEY, dean emeritus of the college of engineering, University of Michigan, and past-president of the A.S.M.E., has been chosen by the Washington Award Commission to receive the award for 1929. The award is given for "accomplishments which preeminently promote the happiness, comfort, and well-being of humanity."

CLARENCE J. KENNEDY has been promoted to plant engineer of the Gary (Ind.) unit of the American Bridge Co., succeeding FREDERICK DENCER, who has been made assistant engineer of the western division with headquarters in Chicago.

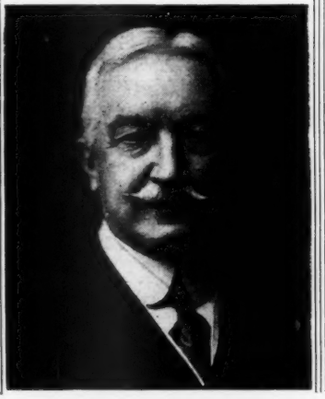
E. J. DEMAS, Washington, D. C., youthful aide to Admiral Byrd, has received a scholarship in the New York University college of engineering after an exchange of radiograms with the Antarctic, where he has been studying for the past two years.

GEORGE G. SMALL, vice-president of the United Engineering & Foundry Co., Pittsburgh, has resigned and will retire from active business. He has been affiliated with the company for 36 years, and was made first vice-president in 1915.

MARIE ROOT



A. A. POTTER



M. E. COOLEY

ROBERT E. KINKEAD, consulting engineer specializing in arc welding, has moved his Cleveland office to the Builders Exchange Building. He has also opened a Chicago office at 330 North Western Avenue.

CARROLL R. HARDING has been appointed assistant to President Paul Shoup of the Southern Pacific Railroad. Mr. Harding is engineer of standards of the railroad and will continue to have charge of the inspection of material and equipment purchased.

S. B. TAYLOR has been promoted recently to assistant works manager of the Reliance Electric & Engineering Company, Cleveland. He began work with the company in 1925 as design engineer of a.c. motors. In 1928, he was advanced to engineer in charge of drafting.

J. A. SUCCOP, research engineer, Heppenstall Forge & Knife Co., Pittsburgh, on Jan. 17 addressed the St. Louis chapter of the American Society for Steel Treating on the "Manufacture and Fabrication of Steel in a Modern Forge Shop."

C. N. BRUBAKER has been appointed managing engineer of the transformer department of the Erie, Pa., works of the General Electric Company, it has been announced by H. L. R. Emmet, works manager. Mr. Brubaker is executive head of all engineering and manufacturing activities of the department.

O. H. HEDRICH, formerly in charge of design and construction for the Municipal Light Plant of Pasadena, Calif., and now associated with the Thomas Machinery Company, has been studying the design and application of electric furnaces in the plant of the Electric Furnace Company, Salem, Ohio, in connection with the assignment of the Thomas Company as representative of the Electric Furnace Company in southern California and Arizona.

E. J. VONDERHEIDE, engineer for the Cincinnati Milling Machine Company, delivered a talk on "Steps Toward Operating-Noise Elimination" at a meeting of the Cincinnati chapter of the A.S.S.T. on Feb. 6.

T. ANDERSON, engineer with the Westinghouse Electric & Manufacturing Co., developed the Ossillograph which is now being used by Wm. Braid White, acoustic engineer of the American Steel & Wire Co., in a study of musical notes leading to the design of a new longer type piano for use in radio broadcasting.

GEORGE B. PEGRAM, dean of the engineering school, Columbia University, New York, has completed plans for a large testing machine to be installed in the testing laboratory of the university. The machine will be able to handle specimens up to 35 ft. long and 6 ft. wide.

H. P. CHARLESWORTH, Bell Telephone Laboratories, New York, has been appointed a member of the Edison Medal Committee of the A.I.E.E. He has also been reappointed to the board of trustees of the United Engineering Society and a member of the group of directors of industrial research.

RALPH M. DUBOIS, formerly engineer with the Continental Motors Corporation, Detroit, has relinquished this position to become chief experimental engineer with the Continental Aircraft Engine Company, also of Detroit.

R. G. WELLS has been appointed chief engineer of the Trundle Engineering Co., Cleveland, to succeed Mr. Eickhoff, recently resigned. PAUL VAN SITTERT has been appointed assistant chief engineer to succeed Mr. Wells.

A. F. YEATON, chief engineer of the Star Drilling Machine Company, Akron, Ohio, has resigned to become sales manager for the International Derrick & Equipment Company, Columbus, Ohio.

GUY L. BAYLEY, formerly head of the Chicago office, Sanderson & Porter, 52 William St., New York, consulting engineers, and HARRISON SMITH, for many years staff engineer for the company, have been admitted to the firm.

PIERRE S. DU PONT, chairman of the board, E. I. du Pont de Nemours & Co., Inc., was the principal speaker at the annual banquet of the Engineers' Society of Western Pennsylvania, on Feb. 3 at Pittsburgh.

H. H. BARNES, until recently works engineer of the Durant Motors Company, Lansing, Mich., has accepted a similar position with the Waco Aircraft Company, Troy, Ohio.

THOMAS J. LITLE, JR., until recently chief engineer of the Marmon Motor Car Co., Indianapolis, has been appointed director of engineering of the Holley Carburetor Co., Detroit.

R. E. HELLMUND, East Pittsburgh, chief engineer of the Westinghouse Electric & Manufacturing Company, was awarded the Lamme Medal of the A.I.E.E., "for his contributions to the design and development of rotating electrical machinery." It is expected that the medal be awarded at the Summer Convention of the Institute, which is to be held in Toronto, Canada, June 23-27.

THOMAS L. COWLES, until recently commercial car engineer of the Studebaker Corporation, has been made assistant executive engineer.

S. H. PAUL has been elected vice-president in charge of engineering of the Nicetown Manufacturing Company, 4250 Wissahickon Ave., Philadelphia.

EDWIN GOODWIN, formerly a consulting engineer, has entered the service of the General Motors Company, Detroit, as a designer.

GEORGE W. DUNHAM, until recently vice-president of the Whirldry Corporation, New Haven, Conn., has opened a consulting engineering office at 535 Fifth Ave., New York. Mr. Dunham, at one time president of the S.A.E., and chief engineer of the Chalmers Motor Car Co., was for many years prominent in automotive work. For the past seven years, he has been identified with the development and production of several electrical appliances, especially for domestic use, including the Savage and Whirldry washers and ironing machines.

H. W. BARLOW, formerly staff engineer in charge of structural analysis and static testing for the Glenn L. Martin Company, Baltimore, has resigned to join the staff of Gazley and La-Sha, consulting aeronautical engineers.

S. E. ROWE has been appointed assistant chief engineer of the Marmon Motor Car Company.

HENRY F. BAILEY, engineer, affiliated for some time with Lockwood Greene Engineers, Inc., New York, has been appointed manager of the Cleveland office.

ERNEST E. EATON, assistant chief engineer of the Brown-Lipe Gear Company, Syracuse, N. Y., has assumed a position of research engineer.

R. D. EASTON, formerly machine designer with R. R. Donnelly & Sons Company, Chicago, is now mechanical engineer.

ELMER H. BABEL was recently appointed chief engineer of the Killifer Manufacturing Corporation, Los Angeles. He was previously mechanical engineer.

H. L. BROWNBACK, until recently engineering director for the Brownback Motor Laboratories, Inc., New York, has resigned that position to perfect advance types of aircraft engines.

R. E. HELLMUND

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GEORGE W. DUNHAM

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Meetings

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS—Annual meeting, Feb. 17-20, New York City. H. Foster Bain, 29 West 39th St., secretary.

SOCIETY OF AUTOMOTIVE ENGINEERS—National Aeronautic Meeting, Hotel Jefferson, St. Louis, Mo., Feb. 18-20, in conjunction with the Aeronautical Chamber of Commerce, as a part of the International Aircraft Exposition. Society headquarters are at 29 West 39th St., New York.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Fiftieth Anniversary Celebration, Opens in New York, April 5, afternoon in Hoboken; April 6 in New York; April 7, 8, and 9 in Washington, D. C. Calvin W. Rice, 29 W. 39th St., New York, is secretary.

SOCIETY OF AUTOMOTIVE ENGINEERS—1930 Summer Meeting, French Lick Springs Hotel, French Lick Springs, Ind., May 25-29. National headquarters are at the Engineering Societies Bldg., 29 W. 39th St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS — Semi-annual meeting, Hotel Book-Cadillac, Detroit, June 2 to 12. Calvin W. Rice, 29 West 39th St., New York City, is secretary.

Obituaries

AUGUSTE C. E. RATEAU, pioneer in the development of the steam turbine, former professor of electrical engineering at the Ecole Superieure des Nimes de Paris, designer of centrifugal compression machinery and the aeronautical engine supercharger, founder and president of the great industrial establishment bearing his name, the Société Rateau, author of engineering papers, medallist, recipient of honorary degrees from universities in the United States, Great Britain, and Europe, and an honorary member of the A.S.M.E., died in Paris on Jan. 13 at the age of 66.

REGINALD H. BULLEY, retired chemical engineer, designer and builder of the Halcomb Steel Works and the first electrical furnace in the United States, died on Jan. 27 at his home in Cocoanut Grove, Fla., at the age of 76 years.

CHARLES G. WADE, 69, consulting engineer, who in the past has been connected with the Allis-Chalmers Manufacturing Company and the Falk Corporation, Milwaukee, died recently at his home in Milwaukee.

DR. JOHN R. BENTON, dean of the college of engineering of the University of Florida, died at Gainesville, Fla., on Jan. 9 at the age of 53 years.

JOHN W. RYAN, 85, who has been retired from active connection with the steel business since 1911, and who was employed by the Cleveland Rolling Mills

Company and the United States Steel Corporation as roll designer for 46 years, died on Jan. 30 at his Cleveland home.

FRANCIS H. TREAT, mechanical engineer and for many years prominently connected with the steel industry, died at his home in Cleveland, Jan. 9, aged 73 years.

HERMAN C. BURGER, designer and maker of highly specialized precision instruments, died in Philadelphia on Jan. 28 in his 69th year.

A.S.T.M. Invites Papers for 1930 Meeting

Members of the A.S.T.M. have been invited to submit offers of technical papers for presentation at the 1930 Annual Meeting. All offers accompanied by a summary and received not later than Feb. 24 will be considered by the Committee on Papers and Publications. Consideration of offers received after that date is entirely contingent upon the condition of the provisional program when the offer is received. Any suggestions in respect to the program should be at hand before the above date in order to receive committee attention.

A.I.M.E. Holds Meeting in New York

A wide range of subjects was included in the papers presented at the 139th meeting of the A.I.M.E., held in New York City, Feb. 17-20, at the Engineering Societies Building. The Institute of Metals division opened its program on Feb. 18, presenting a group of papers, among them a number on metallurgical and metallographic subjects. The Iron and Steel division began its program on Feb. 19 with five papers on ore and foundry practice. On Feb. 20, two sessions were scheduled, the afternoon session dealing with alloy and steel melting. The Howe Memorial lecture "The Future of the American Iron and Steel Industry," was presented by Dr. Zay Jeffries at the close of the afternoon session. The annual business meeting of the Institute was conducted on Feb. 18. Several special excursions were included in the program.

Associated Alloy Steel Sells Three Firms Products

The formation of the Associated Alloy Steel Co., Inc., was announced recently by M. T. Lothrop, president of the Timken Roller Bearing Company, Sevren P. Ker, president of the Sharon Steel Hoop Company, and H. E. Batcheller, vice-president of the Ludlum Steel Company. The company has been incorporated to sell corrosion, sheet, and wear-resisting alloy steel produced by the Timken, Sharon, and Ludlum companies exclusively. These products include Nitralloy, Niresta, stainless steel.

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Research and Engineering in the Capital

By PAUL WOOTON

Washington Correspondent, Product Engineering

ANOTHER step in standardization of specifications will be accomplished this month when the first unified printed specification is off the government press sponsored by the Federal Specifications Board. According to Major Robert W. Voeht, vice-chairman, the Board has to date issued 650 complete specifications of materials and products, but hitherto each of the government departments has had freedom to print its own specifications incorporating the mandatory requirements of the Board. Now each department will use the same printed specification for material that is common to several.

Lock nuts are to be put to a most comprehensive all-around test in the physical laboratory of the Bureau of Standards. The work is sponsored mainly by one manufacturer who wants design data and comparative service information on his own product, but something over 30 other makers are furnishing specimens and will take an active interest in the results. Two research assistants have been furnished the Bureau for the purpose, and special testing machines were designed and built in the laboratory shop. Dr. Herbert Whittemore is in charge.

High hopes of abundant supplies of domestic manganese from the Southern areas, which are held in some commercial circles and have been aired to congressional committees at times, are apparently viewed with scepticism by some of the materials experts in the War Department, who ought to know. Maybe production will last as long as the money lasts, or maybe some company will spring a surprise and produce as cheaply as the foreign producers. Anyway, these military men are not worried. It has been demonstrated that good steel can be made without manganese if need be, and after all what they want is simply the assurance of a good supply of steel to make their products.

If Walter Christie eventually succeeds in building a really practical high-speed tank for the army, the tractor manufacturers can avail themselves of some good design research. So far, the best endurance record is a track that will last about 3,000 miles at 10 miles per hour. Putting the speed up to 30 miles even with hardened and fitted pins brings terrific wear and more terrific noises. For a commercial tractor, a substantial measure of endurance and a minimum of noise are essential. The infantry wants the research carried on and is willing to pay for it. Here is one case where military expenditure may help commercially.

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Important Design Changes Predicted at S. A. E. Annual Meeting

NEARLY 1,000 engineers attended the annual meeting of the Society of Automotive Engineers in Detroit Jan. 20-24. Fourteen professional sessions were held. They dealt with such diversified automotive subjects as: production; research work on riding comfort, high-pressure bearings, fuels, and combustion phenomena; aircraft and aircraft engines; mixture distribution and carburetion, foundry economics; application of tungsten carbide in production work; design of Diesel engines and parts therefor; truck and bus transportation; automobile body design and production; automotive inventions; and front wheel drive cars.

Alfred Reeves, general manager of the National Automobile Chamber of Commerce, expressed the view that comparatively radical changes in motor-car design are likely to be given more consideration in the near future because there is at present too great a similarity between cars of different makes. Many engineers hold the same opinion. Among the developments forecast are several engines with 12 or 16 cylinders, and cars with individually-sprung wheels, front-wheel drives, and lighter bodies.

Discussion at the meeting made it apparent that better utilization of fuel, through improved carburetion and distribution and by the use of combustion chambers of superior design, as well as higher compression pressures, is the subject of wide-spread and intensive research. Rapid advance in Diesel engine design, especially for aircraft and motor truck applications, also is anticipated. That large corporations are keenly interested in well-considered inventions calculated to improve their products was made apparent by a paper on the work of the New Devices Committee of the General Motors Corporation.

A Chart for Determining Bolt Diameters

Contributed by H. M. Brayton, Engineer, Picatinny Arsenal

BOLTS are used extensively to hold machine elements together, particularly where tension stresses are encountered or the elements are to be separable. Ordinarily, in determining what sizes of bolts are to be used in an assembly, a complicated and tedious calculation is required, particularly difficult when the number of threads on the bolt desired is not standard. This calculation becomes even more involved if the designer wishes to select the size of bolt and number of threads to give a fixed fiber stress with a given total load.

To avoid continuous repetition of calculations of this sort, the following relation for a 60-deg. V-thread was worked out; assuming D is the outside diameter of the bolt in in., d is the root diameter in in., P is the pitch of the thread in in., T is the number of threads per in., L is the total tension load in lb., f_t is the fiber stress at the root cross-section in lb. per sq.in.:

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = \frac{\frac{P}{2} - \frac{P}{8}}{\frac{D-d}{2}} = \frac{3P}{4(D-d)}$$

$$\text{also: } L = f_t \frac{\pi d^2}{4}, \text{ or } d = \frac{\sqrt{L}}{\sqrt{0.785 f_t}}$$

Substituting the value of d, given by the latter equation, in the first equation, it becomes:

$$\frac{1}{\sqrt{3}} = \frac{3P}{4\left(D - \frac{\sqrt{L}}{\sqrt{0.785 f_t}}\right)}$$

By substituting $\frac{1}{T}$ for P and simplifying, the equation becomes:

$$D - \frac{1.3}{T} = \frac{1.125\sqrt{L}}{\sqrt{f_t}}$$

Even with this formula available, the process of determining bolt sizes is complicated. The chart on the reverse has been designed to provide a rapid and easy method of solution. It has a diagonal, a horizontal, and two vertical scales, representing the four variables in the preceding equation. When any three of the variables are known, the fourth may be determined from the chart by using two perpendicular lines, illustrated by the perpendicular dash lines shown. The up-and-down dash line is always used to read the horizontal and diagonal scales, the cross dash line to read the vertical scales. One of the lines may be located from two of the three known variables, and the intersecting line may be drawn perpendicular to it from the third known point. The point where the intersecting line crosses the fourth scale is the value of the unknown to be determined.

With this chart and two perpendicular lines drawn on transparent paper or celluloid, the designer can not only obtain the stress in bolts, but can also see how each variable depends on the others. In the solution illustrated, the outside diameter D of the bolt is 1 in.; the number of threads per in. T is 8; and the tension on the bolt L is 10,000 lb. It will be noted that the up-and-down dash line cuts the diagonal scale at about 18,000 lb. per sq.in.—the value for f_t, the unknown fiber stress at the root.

A chart, similar to the one shown, may be drawn by plotting two vertical lines a convenient distance apart to represent the vertical scales. A horizontal line is then drawn perpendicular to both through the base of the left-hand vertical line. By an algebraic and geometric solution unnecessary in this problem, a chart of the sort illustrated may be shown to represent the final equation given above, since it is of the general form $\frac{a-b}{k} = \frac{c}{d}$. In the general equation, if values, or moduli, are assigned for each element, the scales may be graduated and the diagonal scale drawn. In this formula, if m is used to represent the modulus for $a - b$, n for c, and r for d, then $k = \frac{mr}{n}$. For any equation of this type, any values may be assigned to the three other variables, and the equation solved for k, which, in the geometric solution, is shown to be the length of a diagonal drawn from the top of the left-hand vertical scale downward to intersect the right-hand vertical scale. It is not shown in heavy lines since it is not essential in solutions of bolt problems. In the chart shown, the following values for each modulus were selected: $m = 6$, $n = 0.04445$, and $r = 0.0593$. Then $k = 6 \times \frac{0.0593}{0.04445} = 8$ in. The diagonal scale f_t is drawn from the intersection of the horizontal scale and the left-hand vertical scale perpendicular to the diagonal k and is thus located. The modulus may be assigned any values which will bring the diagonal within the limits of the chart and give the desired graduations on the scales. These graduations are next determined by using straight-line equations for each scale, thus:

$X = mD = 6D$ (Equation for the left-hand vertical scale)

$Y = m\frac{1.3}{T} = \frac{7.8}{T}$ (Equation for the right-hand vertical scale. The value of Y is measured downward from E)

$Z = n \cdot 1.125\sqrt{L} = 0.05\sqrt{L}$ (Equation of the horizontal scale)

$Q = r\sqrt{f_t} = 0.0593\sqrt{f_t}$ (Equation of the diagonal scale)

If arbitrary values are now assigned to the variables D, T, L, and f_t in these equations, these variables can be solved for the distances X, Y, Z, and Q, and the points on the respective scales can be plotted. Zero on the vertical scales is, in each case, at the crossing points of the diagonal, k. For the diagonal and horizontal scales, zero is at their intersection. All scalar distances are measured in the same units—inches in this example.

A chart so constructed can be read by two perpendicular lines because they cut out similar triangles. This may be proved by the usual geometric solution, if desired.

For example, when the diameter of the bolt D is 1.5 in., the distance from the upper end of the left-hand vertical line down to the point marked 1.5 in. should be 9 inches.

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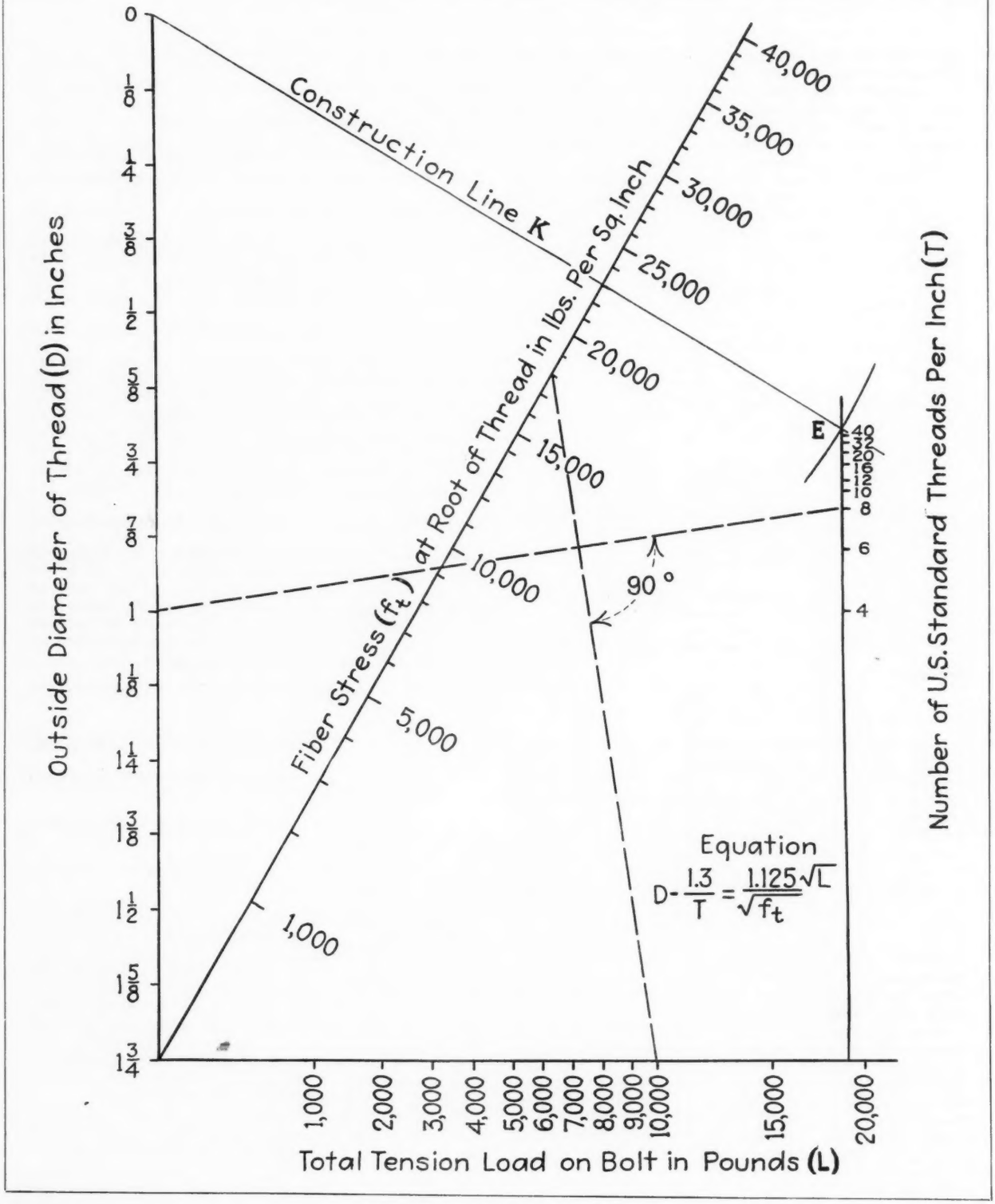
A Chart for Determining Bolt Diameters



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